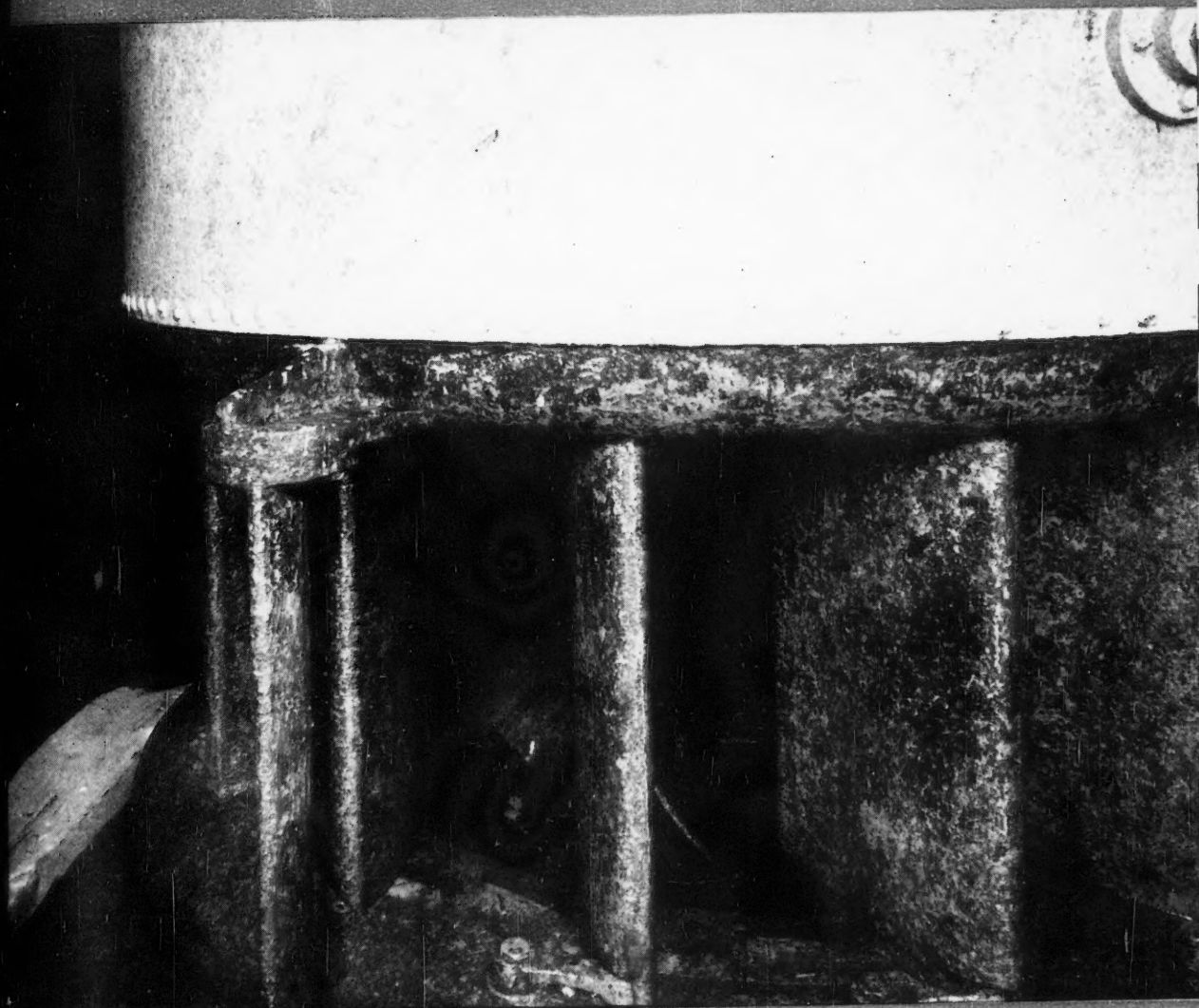


Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



Vol. 6

OCTOBER, 1950

No. 10



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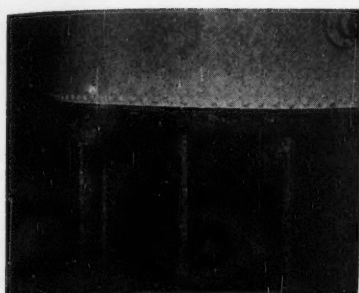
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THIS MONTH'S COVER—Wicker gates of a water turbine shown after chipping and wire brushing before application of a 5-coat vinyl system. Two-year tests of eight turbines show the coating effectively reduces corrosion to a minimum, prevents accumulation of marine growth, and increases efficiency up to 10 percent above normal because of reduced friction. This photograph is of installation coated by Plastic Lining Corp., Chicago, Ill.



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Corrosion is Indexed Regularly by Engineering Index.

Corrosion

devoted entirely to

CORROSION

Research and Control

Published monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., to provide a permanent record of progress in the control of corrosion as described in papers prepared for the Association and from other sources.

Vol. 6

OCTOBER, 1950

No. 10



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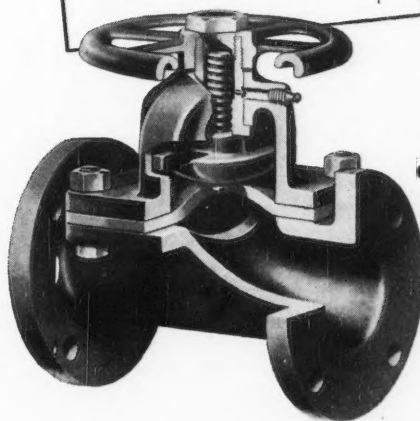
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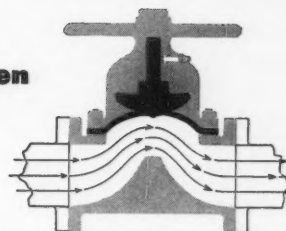
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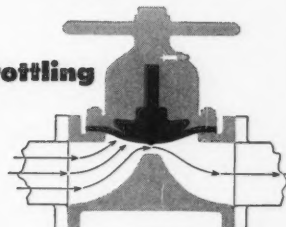


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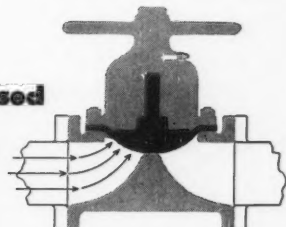
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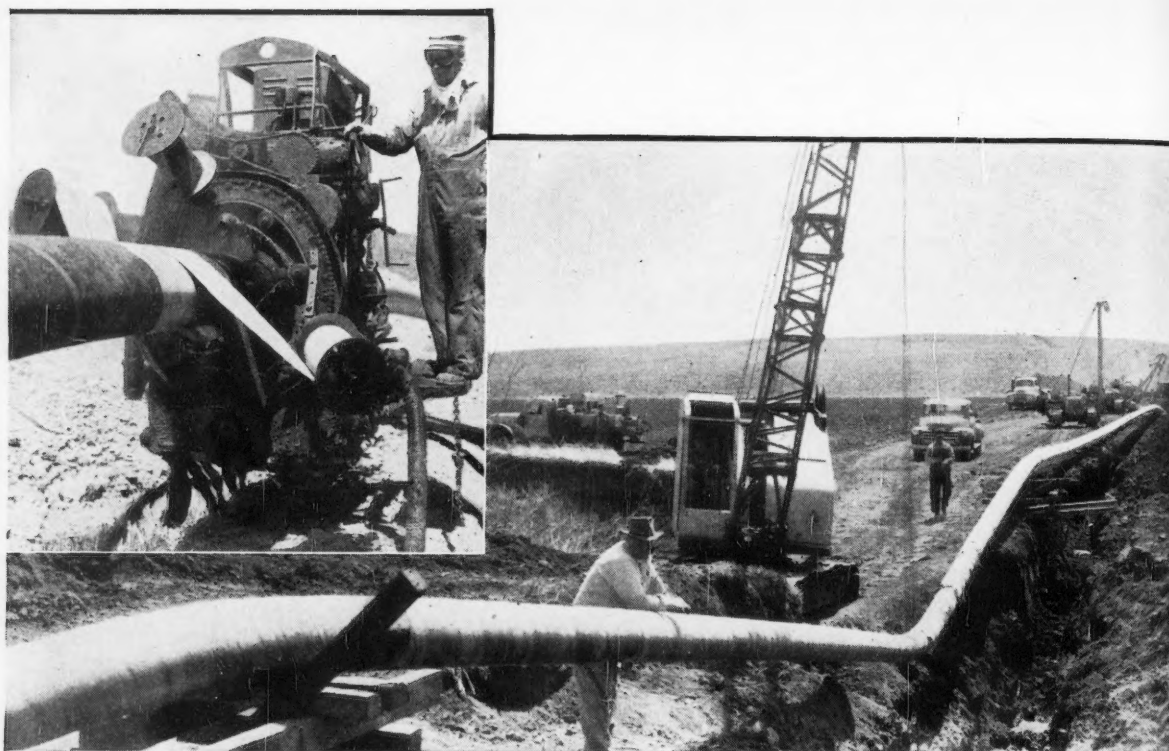
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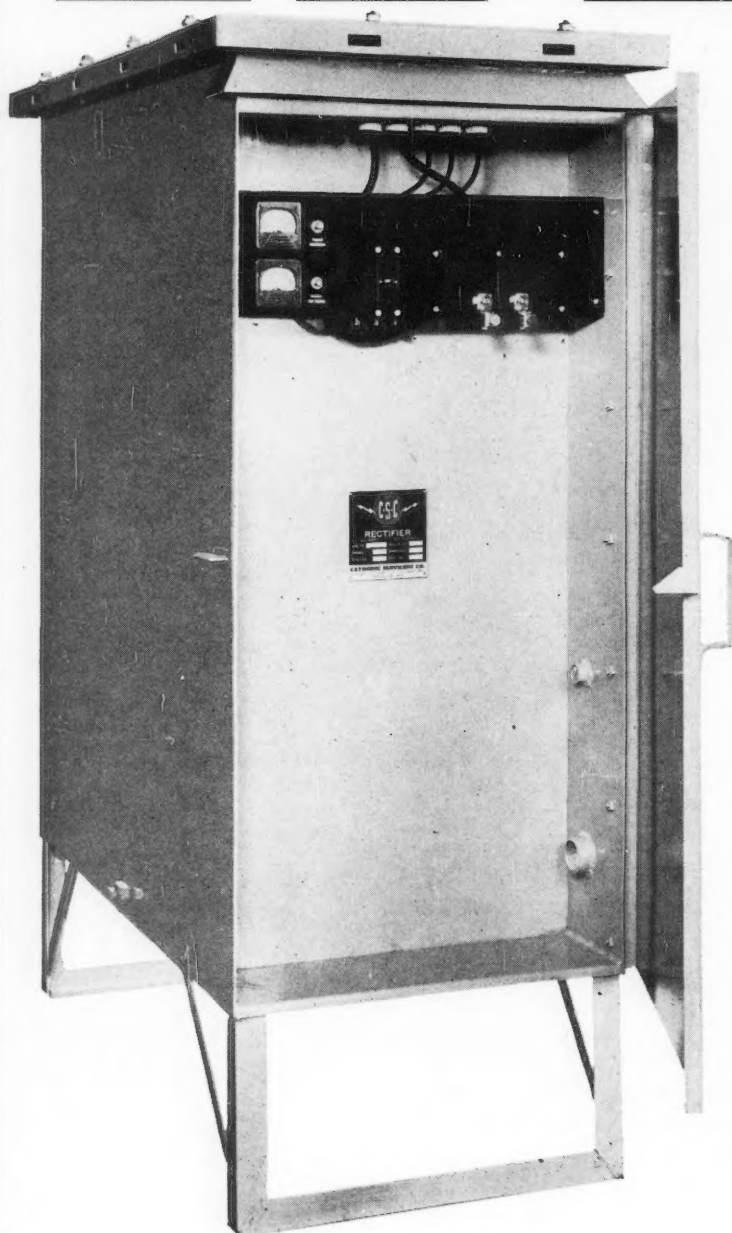
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Selection of Protective Coatings for Chemical Fume Resistance★

By CLARENCE C. HARVEY

Introduction

IN INDUSTRY the principal function of an organic coating is the protection of metal equipment against deterioration. Since atmospheric corrosion is the principal cause of such deterioration it is necessary that protective coatings both shield the metal against corrosion and withstand the environmental factors which cause attack. Many test procedures have been devised to measure the relative performance of coatings from both of these standpoints for normal environments. However, little has been reported on tests designed to select coatings for atmospheres contaminated with chemical fumes which are destructive to both equipment and coatings.

The effects of the natural elements, such as rain, humidity, sunlight and temperature, on coatings have been studied in weathering tests for many years. In these tests the extent of protection as well as deterioration of the coatings are usually evaluated. Much of the real progress in the field of protective coatings can be ascribed to the careful evaluation of panels exposed to the weather. Accelerated tests in weatherometers, humidity cabinets and other laboratory tests have served as useful adjuncts to weathering studies by screening out the less satisfactory materials.

In those services where physical abuse factors outweigh the normal degradation factors, physical property tests have proved valuable in making coatings selections. Physical tests are designed to evaluate one or more of the following properties: adhesion, abrasion resistance, distensibility, hardness and resistance to scratching or impact. During the past few years considerable effort has been directed toward improving tools and test procedures to make such evaluations. Compton has emphasized the importance of such tests in the selection of coatings for any service.¹

In addition to the normal weathering and physical abuse factors, both coatings and equipment are frequently attacked by chemical fumes. Such fumes are particularly destructive when steel is the principal construction material, since they accelerate the normal rusting process to a marked degree. In chemical plants where fume conditions are encountered, protective coatings are called upon for probably their most difficult role. Many of the more common organic film formers are subject to rapid degradation in atmospheres containing either acid or alkaline fumes and dusts. There is, however, little information in the literature on this subject. Most frequently, tests of coatings under a wide range of fume conditions are grouped into one general classification, and

CLARENCE C. HARVEY has served Ethyl Corporation as development chemist in various fields since 1941. For the past four years his principal efforts have been in corrosion engineering with special attention to materials of construction for going processes and new developments. He holds an MS from the University of Mississippi and currently is active in corrosion committee work with the American Petroleum Institute and the American Society for Metals.



Abstract

Emphasizes the need for coatings to meet specific fume conditions, such as sulfur di- and trioxide, hydrogen sulfide, nitric oxides, chlorine, and hydrogen chloride gases or vapors in chemical plants, refineries, paper plants, and other corrosive environments.

referred to as "industrial atmosphere" tests. Thus, those interested in protecting equipment against specific fume conditions are usually left with but one course of action: to test various coatings under their exposure conditions.

Nature of Fume Attack

Some of the most common industrial fumes which can lead to premature coating failures are listed in Table I together with some of the operations in which such fumes are encountered. Sulfur trioxide and sulfur dioxide in the presence of moisture and oxygen precipitate a film of dilute sulfuric acid on exposed surfaces. The presence of this acid film causes most coating vehicles either to age at a very rapid rate or to break down chemically. It also at-

TABLE I—Industrial Fume Conditions

Fume	COMMON Sources	
1. Sulfur Dioxide	Refrigeration Bleaching Fumigation	Sulfur-bearing Coal Pulp and Paper Processing
2. Sulfur Trioxide	Sulfonations Petroleum Refining	Sulfuric Acid Manufacture
3. Hydrogen Sulfide	Sewage Disposal Sour Crude Processing	Viscose Rayon Manufacture
4. Nitric Oxides	Dye Manufacture Explosives Manufacture	Fertilizer Manufacture Nitric Acid Manufacture
5. Chlorine	Chlorination Bleaching	Chlorine Production
6. Hydrogen Chloride	Metal Processing Hydrohalogenation	Hydrochloric Acid Manufacture
7. Ammonia	Refrigeration	Ammonia Production

★ A paper presented at the South Central Regional Meeting of the National Association of Corrosion Engineers, Dallas, Texas, October 3-4, 1949.

tacks many of the common pigments to form highly hydrated salts within the coating. Hydrogen sulfide, nitrogen oxides, and hydrogen chloride fumes produce similar acid film attack of coatings. Chlorine fumes attack many coating vehicles and pigments directly to produce embrittlement, flaking, and blistering failure. Ammonia fumes produce typically alkaline breakdown of many coatings. Most of these materials also stimulate underfilm attack so that mere envelope protection oftentimes fails to give the degree of protection desired. In general, the more highly corrosive the environment is to the uncoated construction metal, the more difficult the coating problem.

A. J. Arker and W. R. Frisch² have reported an accelerated test for evaluating the relative protection merit of various coating systems in a sulfur dioxide atmosphere. In their experiments, panels coated with various organic films were exposed to moist sulfur dioxide at 127° F. for a few hours during which time most coatings were severely attacked. Evaluation of the attack was made by weighing the panels before and after the test, with those suffering the most severe attack gaining the most weight. Good reproducibility was reported with this test method although no correlation with field tests was reported.

W. F. Singleton and W. C. Johnson³ evaluated various organic coating materials for ammonia fume service by exposing coated panels to fumes above 1 percent ammonium hydroxide. Permeability and adhesion were evaluated separately as important factors aiding in selection of coatings for an ammonia fume condition. No correlation with field tests was reported.

Integrated Test Program

In setting up tests to select coatings for hydrogen chloride and chlorine fume resistance an integrated test program was judged to be most useful. Laboratory screening, field panel tests, physical property evaluation and performance tests on operating equipment were all believed important in making practical selections of coatings. As a first step an accelerated laboratory test procedure was developed. This procedure permitted screening out the less satisfactory materials. In this test dip-coated mild steel panels measuring $3 \times 1 \times \frac{1}{4}$ -inch with rounded corners and edges were exposed to the fumes above 15 percent

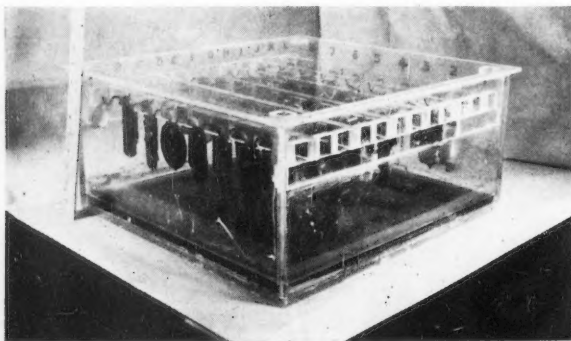


Figure 1—Hydrochloric acid fume cabinet.

RATING	CONDITION OF COATING	EXAMPLE
1. EXCELLENT	COATING AND PIGMENT UNAFFECTED GOOD PROTECTION OF METAL	
2. GOOD	COATING AND PIGMENT RELATIVELY UNAFFECTED SLIGHT METAL ATTACK AT EDGES AND SUPPORT HOLE	
3. FAIR	COATING OR PIGMENT ATTACKED SLIGHTLY (SOFTENING, FADING) SLIGHT BLISTERING, CRACKING OR UNDERMINING OF COATING	
4. POOR	COATING OR PIGMENT SERIOUSLY ATTACKED SERIOUS BLISTERING, CRACKING OR UNDERMINING	
5. VERY POOR	COATING OR PIGMENT SERIOUSLY ATTACKED NO EFFECTIVE METAL PROTECTION OVER 50% OF PANEL AREA	

Figure 2—Fume cabinet rating system.

hydrochloric acid at room temperature (Figure 1). A variation of this procedure consisted of exposure of panels to about 0.05 percent chlorine fumes saturated with water. The hydrochloric acid cabinet was chosen as the simpler and more effective test and was used much more extensively than the chlorine cabinet.

Test panels were examined and evaluated about every two weeks. The rating system used for evaluating the coating materials is shown in Figure 2 together with representative examples of the five failure conditions. Emphasis was placed on attack of the coating rather than on protection afforded the metal. Failures at the support hole or edges were graded less severely than failures on flat surfaces. The length of time required for a coating to reach a rating of "3" in the system was used as the basis for screening out unsatisfactory materials. Those which failed within one month were not tested further, since the unsatisfactory coatings previously used in the field failed on exposures of one month or less in the fume cabinet.

Field Panel Tests

Two field test sites were used to evaluate further the relative merits of various coating systems which appeared promising in the fume cabinet tests. The first site was chosen for the severity of the fume conditions. Test panels were located on an operating unit which produces hydrogen chloride gas (Figure 3). At this site 6×10 -inch panels of 18 gauge mild steel were coated with the systems to be tested and suspended vertically from structural members. The second test site was located more than 150 feet from any operating unit and represented a mild or negligible fume condition (Figure 4). Here weathering resistance was measured on a typical weathering rack with 6×10 -inch panels exposed at an angle of 30° facing south.

Separate evaluation of weathering and fume resistance of coatings was thought necessary, since both extremes were not present in most locations. Most

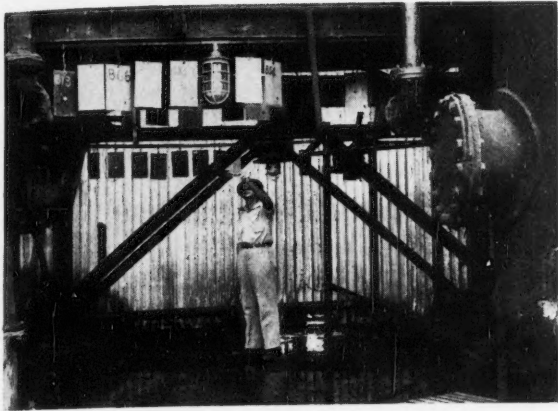


Figure 3—Field fume test site.

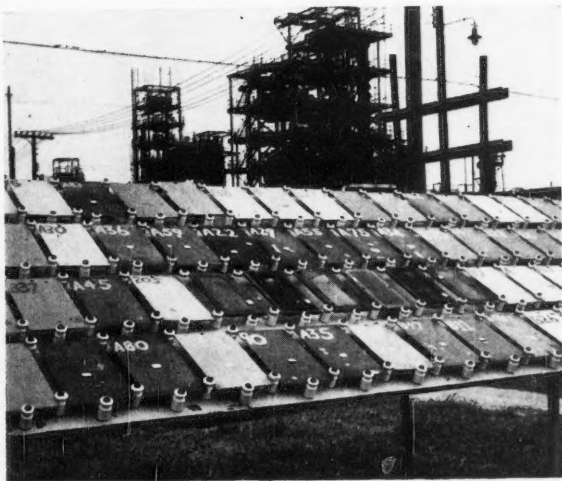


Figure 4—Weathering test rack.

RATING	PANEL CONDITIONS	EXAMPLE
1. EXCELLENT	NO FILM FAILURE SLIGHT STAINING OR FADING METAL PROTECTION EXCELLENT	
2. GOOD	MINOR FAILURE ON EDGE OR IN LIMITED AREA DUE TO FAULTY APPLICATION LESS THAN 2% FAILURE FADING, CHALKING, CHECKING	
3. FAIR	2 TO 5% OF AREA CORRODING SLIGHT BLISTERING, CRACKING TOUCH-UP REQUIRED	
4. POOR	5 TO 15% FAILURE BLISTERING, CRACKING REPAINTING REQUIRED	
5. VERY POOR	MORE THAN 15% FAILURE SEVERE COATING DETEIORATION EXTENSIVE CLEANING AND REPAINTING REQUIRED	

Figure 5—Field test panel rating system.

of the equipment in the area where the possibility of fumes existed was subjected to milder conditions in both respects than at the test sites. It was thought that coating systems which performed well at both sites could be construed to be generally applicable throughout the area where the possibility of fume conditions existed.

Field conditions of surface preparation and coating application were simulated as closely as possible on panels exposed at both sites. In the maintenance of plant equipment, surface preparation prior to painting consisted only of chipping and wirebrushing to remove heavy scale, rust and loose paint. Sandblasting, flame-cleaning, and other methods were not applicable in the plant because of the fire hazard and possible damage to instruments and motors on operating units. Consequently, in the field tests coatings were applied to panels which had been pickled to remove mill scale, deliberately rusted and wirebrushed. Proprietary coating formulations were applied by either brushing or spraying without great attention to techniques in order to simulate normal field application. However, the thickness of each film was measured after application with a G. E. film thickness meter to measure the effect of film thickness on coating performance.

Field test panels were rated on a slightly different basis than fume cabinet panels (Figure 5). Here, emphasis was placed on metal protection rather than coating integrity. Failures of the type which resulted in metal attack were graded severely. Relative performance values were based on length of service prior to reaching the failure condition "3." This condition was chosen as the most favorable for repainting. The primer coat at this stage is still in generally good condition and only a few localized failures require touchup with primer prior to recoating with the finish. Costly paint removal and descaling procedures are avoided with maintenance of coatings at or above the failure condition described as "3" in the rating system.

In tests involving 295 selected proprietary coating formulations, vinyl and asphalt mastic coating vehicles exhibited superior resistance to hydrogen chloride fume conditions. Carbon black, titanium dioxide, chromic oxide and the organic pigments toluidine red, phthalocyanine green, phthalocyanine blue and hansa yellow were the most satisfactory finish coat pigmentations tested. The use of a primer on the rusted field test panels appeared to be essential to good performance in any coating system tested. Red lead was superior to zinc dust or zinc chromate as the inhibitive primer pigment. Medium oil alkyd primers containing free linseed oil to improve wetting characteristics, exhibited superior performance in a system, although they were less resistant when not protected by finish coats. Surprisingly, wire-brushed rusty panels performed as well as, and in most cases better than, clean, pickled or sandblasted panels when systems incorporating primers with good surface wetting properties were used.

Although the laboratory panels and field fume test panels were graded on somewhat different bases,

fairly good correlations were obtained with most of the coating systems tested. In general, the nature of the attack in the field fume tests was similar to that obtained in the laboratory fume cabinet. Blistering and under-rusting were the most common forms of attack with the more chemically resistant coatings. Failure occurred about three times as rapidly in the fume cabinet as at the field fume test site.

However, there were notable exceptions in that some of the coatings performed well for up to two years in the fume cabinet, yet failed within six months in the field. Such exceptions were due principally to the more careful surface preparation and application of coatings to the laboratory panels. Each of the exceptions involved coatings with poor wetting characteristics which could not be expected to penetrate a rust film and seal voids effectively in the field panel tests. There was little correlation between results obtained on the weathering test rack and those obtained either in the laboratory or field fume tests, although several coating systems performed well under all service test conditions.

Field Tests on Equipment

In addition to the field panel tests, some of the more promising systems were applied to selected pieces of equipment in the plant area where fume conditions were most severe and where weathering factors would also be involved. The coatings were applied by the regular painting crews in order to include field techniques of surface preparation and application. These applications served as the basis for final selection of coating systems for fume conditions.

Two coating systems proved outstanding in the field equipment tests. The first consisted of a medium oil alkyd red lead primer with a heavy application of

asphalt mastic as a finish. This mastic was a proprietary formulation containing gilsonite with asbestos and mica as fillers and was preferably applied by spraying. The second consisted of the same type of primer with a "flat" chlorinated rubber barrier coat and two vinyl finish coats. The barrier coat was employed primarily to prevent the solvents in the vinyl finish coats from "lifting" the primer coat.

Summary

The most satisfactory approach to selection of coatings for specific fume conditions appears to be the use of an integrated test program. Laboratory screening tests, panel tests located in the plant, and tests on operating equipment all contribute to the development of an appropriate coating system. In the laboratory, an accelerated test with more concentrated fumes than encountered in field service permits rapid screening of a large group of materials. Field tests on panels of moderate size should be located in the plant where fume conditions exist. Supplementary weathering data may also be desirable. Field techniques of surface preparation and coating application should be simulated in preparing field test panels. Tests on operating equipment are essential to the final evaluation of the most appropriate coating systems.

References

1. K. G. Compton, "Selection of Protective Coatings for Metals," *Corrosion* **4**, No. 3, 112-22 (1948).
2. A. J. Arker and W. R. Frisch, "An Accelerated Test for Evaluating the Protective Power of Finishes Against Sulfur Dioxide," *Organic Finishing* **9**, No. 5, 9-19 (1948).
3. W. F. Singleton and W. C. Johnson, "Moisture-Resistant Coatings for Metal," *Industrial and Engineering Chemistry* **41**, No. 4, 749-53 (1949).

DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in *CORROSION*, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make *CORROSION* more valuable to the membership.

Report on Round Table Discussion On General Corrosion Problems*

By F. L. LaQUE*

Preface

The periods devoted to round table discussions of general corrosion problems and of pipe line corrosion problems were two of the highlights of the April, 1950, Corrosion Conference in St. Louis. Delegates and members submitted many questions prior to the meeting. As time permitted, a limited number were discussed.

Those in attendance were able to both contribute and receive information and to evaluate it in terms of their own experience. For these reasons these round table discussions were most interesting and informative.

At the General Corrosion Problems Round Table each discussor was requested to submit a resume of his remarks for use in preparing answers for publication. These discussions were "off the record" and no one was quoted directly. These written answers were collected and edited by the leader, F. L. LaQue, and are presented below. Since only a limited number of questions could be taken up in the allotted time the remaining questions have been submitted to the editor of the "Questions and Answers" Department of CORROSION.

While these brief answers will prove useful, a written report on this type of program cannot substitute for attendance and participation.

Question: What is the cause of severe internal tubing corrosion of high pressure (3000-4000 psi tubing pressure), high GOR (6,000-10,000), sweet oil wells producing less than 0.2% water? What can be done to combat this type of corrosion?

Answer: Such corrosion is believed to be caused by the presence of CO_2 dissolved in the water which leaves the reservoir as a vapor, and condenses on the pipe walls. The pH of the water is 4.5 to 5.0. Baker on phenolic coatings, nickel plated steel, 9% nickel steel, and the addition of inhibitors are all being tried. The problem is under study by NACE TP-1 committee, and was discussed in a paper by R. C. Buchan, entitled "Corrosion in Condensate and in High Pressure Sweet Oil Wells" presented at the 1950 conference, and published in CORROSION magazine, June, 1950, pp 178-185.

Question: Are there corrosive media which cause intergranular corrosion of type 347 stainless steel, adjacent to weld deposits, which areas have been heated into the sensitizing temperature range?

Answer: One speaker referred to red fuming nitric acid as causing such attack. However, his written remarks were not received.

Another commented that he has observed similar intergranular corrosion of type 347 stainless, when sensitized in the intermediate temperature range of 600° C, when immersed in hot nitric acid-hydrofluoric acid mixtures. The same type steel, when properly water quenched from 1100° C (2010° F) did not so corrode. This was described in a paper published by Uhlig in the Trans. Electrochem. Soc., Vol. 87, 204 (1945).

Question: What are the conditions causing deterioration of tin and tin plate by phase change at cold temperatures from Beta to Alpha tin, and what are the methods of preventing such change?

Answer: One replier stated that he had tried to transform tin to gray tin by inoculation and low temperature treatment, but had not been successful. He could get gray spots, which were corrosion products, by exposing tin or tin coated copper to a humid atmosphere. It was suggested that the case under discussion was due to corrosion rather than a phase change.

Question: What mechanical methods for external protection of cooling tower pipe, headers and coils have been successful when cooling water has a high concentration of chlorine? Would magnesium anode shields work in such cooling towers?

Answer: No mechanical methods were suggested. If the originator of this question refers to protection of surfaces in contact with water sprays, and not completely submerged, cathodic protection by sacrificial anodes would not be possible for lack of a continuous electrical path through the electrolyte. If the chlorine is present as an addition to function as a germicide and algicide, it was suggested that other reagents be used, such as rosin amine acetate, chloramine, quaternary ammonium compounds, etc., which do not produce a corrosion problem.

Question: What inspection methods are recommended for locating severely corroded areas of vessels or piping for closer scrutiny by more precise methods or instruments such as an Audigage?

Answer: Both the Penetron and the Audigage are useful for determining thickness of vessels. The Penetron does not require surface preparation while the Audigage or Sonigage do require a reasonably smooth surface. One commentator stated

* A discussion session held during the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

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that in his plant they determine areas where corrosion is most likely to occur by working in close harmony with the plant superintendent and his staff. On pipelines measurements are generally made at changes in direction of flow, such as elbows, tees, valves, etc., and by periodic checking, one can determine when replacements should be made to prevent actual failure of the equipment.

Question: Could someone give an explanation for the cause of corrosion of copper grounding screens at a radio broadcasting station?

Answer: An insufficient description of the case has been presented to give an adequate answer. It was suggested that corrosion might be due to placing the copper on a cinder fill.

Question: What are the relative welding characteristics and corrosion resistance properties of extra low carbon stainless steels as compared with the columbium or titanium stabilized grades?

Answer: Most of the comments regarding this discussion were not received in writing.

One commentator mentioned that despite the use of 0.03% C plate and weld rod, it is almost impossible to produce field welds having less than about 0.045 to 0.06% carbon. This may not be serious when the construction is limited to single weld seams, but where a weld intersection occurs, it is possible that carbide precipitation will occur in the first weld deposit as a result of the heat developed in depositing the intersecting weld.

Outside of a possible problem in producing extra low carbon weld deposits it would appear from available data that the steels containing less than 0.03% carbon compare very favorably with the columbium or titanium stabilized grades with regard to freedom from intergranular corrosion after welding or stress relief annealing as well as overall resistance to chemical attack.

Question: We would appreciate a discussion of unpublished data regarding the tendency of authentic stainless steels to fail by stress corrosion when in contact with hot brackish water.

Answer: One refinery lost a type 304 stainless steel tube bundle due to stress corrosion cracking after six days operation handling a cooling water containing about 1700 ppm chlorides. The cracks were about 4 to 6 inches from the end of each tube sheet. It was fairly well determined that the stresses were concentrated at these locations due to bouncing of the bundle during a truck shipment of 70 or 80 miles from the manufacturer to the user.

Difficulties are most likely to occur where there is a chance for surfaces under stress to reach temperatures high enough to effect an appreciable concentration of the chlorides in the cooling water—as in the case of cascade coolers handling hot gases within the tubes.

Question: What is the feasibility of using vinyl primer, similar to USN #117 Metal Conditioner,

as a shop coat over steel and 61ST Aluminum when these plates are to be stored outside?

Answer: Steel is reported to perform satisfactorily when so coated, but some experience with aluminum, cleaned with mineral spirits, has shown blistering and flaking. Flakes examined were approximately three times the dry film thickness of 0.3 to 0.5 mils which is recommended. Cleaning with toluol-ketone mixtures gave noticeably better adhesion. Paint systems, both vinyl and other topcoats over vinyl wash primer, have performed remarkably well on aluminum siding, etc., over a period of years. In these cases, however, the wash coat primed surfaces were stored indoors before application of the finish coats.

Question: Have any successful coatings been developed for application to the interior surfaces of steel storage tanks handling straight run distillates from high sulfur crude oils?

Answer: High polymer vinyl resin coatings have been successfully used for protection of the vapor phase surfaces. Surface preparation of the steel is very important and may involve both sandblasting and flame cleaning. Film thicknesses of five to six mils are suggested, which are obtainable by the application of 4 and 5 coats.

Sour distillate run down tanks, 40' diam. by 10' high, have been so coated in the Gulf Coast region, and have been in service for one, two, and three years. Opportunities to inspect these coatings have not been possible since operation demands have required continuous use of the tanks. Some of these roofs require replacement in three years if not painted. There are indications that an extended life of even six months would prove such coatings to be economical.

One installation on the West Coast has been in service three years. In the Chicago area similar installations have been in service 3½ years. In Oklahoma sour crude run down tanks have been coated top and bottom for the last five years.

Question: How do the lives of sprayed zinc coatings compare with galvanized coatings in atmospheric exposure?

Answer: Since the lives of zinc coatings in atmospheric exposure are a function, generally, of the coating thickness, and since sprayed coatings are generally applied many times thicker than are galvanized coatings, it is almost impossible to compare the two.

Sprayed coatings are usually porous. Whether they will give sacrificial protection is not known, according to the replier to this question.

Question: What uses have been made of Teflon, both as a coating, and as a solid material, in the chemical industries? What are some of the difficulties?

Answer: The consensus of the various repliers to this question was that the use of Teflon as a coating has not yet reached the point that service records are available.

One replier stated that the Teflon film was sub-

ject to "mud cracking" unless applied to a mirror-like surface, since a rough surface would cause excessive thicknesses in the depressed areas, and the excessive thickness tends to mud crack during drying.

As solid material the use of Teflon as a packing and as a gasket material was mentioned as the major application in chemical process equipment. It was mentioned that thin Teflon sheet can be used as an envelope over or around pliable gasket materials, thus permitting good shape formation and pliability when used on non-uniform surfaces.

Question: In selecting an inhibitor to prevent corrosion of installations in sour crude and gas condensate wells, which would be more desirable: a) An oil soluble, brine dispersible inhibitor; b) A brine soluble, oil dispersible inhibitor.

Answer: This question is too broad to answer briefly. No general statement can be made regarding the type of inhibitor best suited to combat corrosion. The selection of the inhibiting agent should be governed by laboratory and field studies in order to insure the best possible material for the problem.

In sour crude oil wells two general types of inhibitors are used. One, formaldehyde, is water soluble and seems to work satisfactorily in Kansas but does not function properly in West Texas. The chief difference seems to be that Kansas wells generally are high water producers while the West Texas wells are relatively low water producers. We have used this reasoning and so far it has been satisfactory, in sour crude oil wells producing a large amount of water. The other inhibitor used in sour crude oil wells is the organic or polar type; we believe the best of these are the oil soluble materials. Protection against corrosion is obtained in those cases where the most effective agent is selected for the particular crude and care is used in injecting in the proper concentrations. These materials should be used with caution as some crudes respond to comparatively few polar inhibitors.

In condensate wells, consideration should be given to the type water produced and the cost of treatment. In general, if the produced water is of the low total solids variety, (below 2000 ppm) the water soluble inhibitors such as the alkaline or neutralizing type and the chromate type are very effective and less costly than the organic or polar oil soluble materials. However, in wells producing highly mineralized water, only oil soluble polar materials can be used. Here too, care should be exercised in the selection of the most suitable inhibitor for a particular well. The analysis of the water should be the first consideration, followed by sufficient laboratory and field testing to insure the selection of the proper inhibitor.

The method of well completion is a factor to be considered in determining the method of injecting the inhibitor.

Question: Is there any information available concerning the effect sulfides or other organic acids

in Lub distillates may have upon acceleration of corrosion of carbon steel furnace tubes in the solvent lub-oil extraction process which employs furfural?

Answer: It has been established that the corrosiveness of furfural is very sensitive to the presence of organic acids, even in small quantities. The corrosivity of furfural extracts of lubricating oil increases rapidly when temperatures are raised above 430-450° F., which may be due to decomposition of the furfural.

Question: What can be done to reduce corrosion resulting from CO₂ in steam condensate systems? (Evaporators and condensate return lines.) Information regarding vaporizable amines for high pressure boilers. A condensate to be considered contains up to 10 ppm CO₂ at a pH as low as 5.8.

Answer: Use of ammonia or sodium hydroxide to neutralize the carbonic acid in the condensate was suggested. Such treatment may be made at condensate accumulating tanks prior to pumping back to the boiler houses. Sufficient NaOH additions to raise the pH of the condensate to 8.0 or 8.5 was suggested.

Where high CO₂ exists in steam, the feasibility of reducing the bicarbonate hardness of the boiler feedwater also should be investigated.

One practical means of extending the life of horizontal tubular steam heaters, where corrosion normally is most severe along the bottom, is to construct the tube bundle so that it may be rotated in 90° increments periodically and thus expose an unattacked surface along the bottom before failure occurs. By such means the useful life of steam reboiler tubes has been increased up to 3 times the life of tube bundles which were not rotated.

It was mentioned that ammonia had been used with success to neutralize CO₂ except that the water was not recoverable for use in either 400 or 1200 psi boilers.

The use of aluminum alloys for handling steam condensates was suggested. Such alloys were reported to be virtually completely resistant to all combinations of CO₂, steam, and or oxygen, under condensing conditions. One chemical plant used aluminum heat exchangers condensing 25 psi steam containing considerable CO₂. Soda ash producers use aluminum tubes in their ammonia recovery systems where combinations of NH₃, CO₂ & steam are encountered. Service lives of over 10 years are common. A large number of aluminum steam jacketed kettles have been successfully used for many years in the food industry.

A paper entitled "The Effect of Non-Condensable Gases on Corrosion of Nickel in Steam Condensate" by W. A. Wesley & H. R. Copson, appeared in the May, 1949, issue of the Journal of the Electrochemical Society. Some alloys other than nickel are also discussed in this paper.

As regards vaporizable amines, no suggestions were forthcoming.

Question: What experience is there with aluminum and Alclad tubes in salt water-cooled heat exchangers, especially in the Gulf Coast area? Is there any information as to the minimum water velocity permissible with respect to pitting attack? It is realized that higher velocities are favorable to freedom from pitting attack.

Answer: In an article in the October, 1947, issue of *Industrial & Engr. Chemistry*, Brown & Verink reported experience with 2½" tubing (Alclad 3S), experimentally rolled into cast iron tube sheets. The coolant was water from the Gulf of Mexico flowing at a rate of 4 ft./sec. After a year under these unfavorable conditions the cladding was removed for a distance of 10 inches with negligible penetration into the 3S core, even at the junction between the aluminum and cast iron. As a result of these tests Alclad tubes were put into service with aluminum sheets. Obviously under the present conditions the consumption of the cladding is at a very reduced rate.

In answer to the second part of the question, some 3S Alclad tubing has been in operation for 5 months with a water velocity of 2 ft. per second and has remained in good condition over this period.

Question: What physical and chemical changes take place when protective coatings fail?

Answer: The term, "fail," is interpreted to mean the end of useful life rather than abnormal performance.

The work on how protective coatings come to the end of their useful life or fail has been largely empirical in nature. Some fundamental work is being done. It is known that a paint, for example, applied over another paint which has not dried, will result in wrinkling leading to checking and flaking.

We know that primers applied to a poorly or improperly prepared surface will not perform well. Just why these phenomena occur, we know little.

The question is the foundation of all paint, pigment and vehicle research. If we only knew the reason for paint failures the appropriate measures to take to delay failure would perhaps be very obvious. The end of useful life in a paint film is produced by a combination of physical and chemical reactions or adjustments. Chemical changes are always measured by and deduced from certain physical changes. The lack of precise and quantitative measurements on the physical properties of paint films of various types, after various exposure histories, is serious. The question can be raised as to what physical properties could be measured and what they would tell us in terms of the paint film. I will mention a few here that are of special interest.

The paint film undoubtedly changes in structures as it ages, since everyone has observed the transition from wet paint to a dry elastic film, to a hard brittle coating. This structural change is perhaps accompanied by a change from a colloid dispersion to a gel and finally to a true and prob-

ably multiphase solid. At some point in this process the structure ceases to perform its required function and we say it has failed, if the performance is not in accordance with expectations based on experience—or it has reached the end of its useful life if the performance is what we have come to recognize as normal for the type of coating. The actual dimensions of the molecular structures in the paint film could be measured by X-ray and electron diffraction techniques as the process continues.

The chemical changes in a paint film do not cease when the paint is canned nor when it has dried after application. These chemical reactions may be responsible for physical structure changes and their presence would be determined by diffraction techniques. There are certain bond changes that would accompany the oxidation of the organic drying oils that could be followed by infra-red absorption spectrometric methods. Likewise the formation of metal-organic complexes would probably be detected by these methods.

The arrangement of the pigment particles in a paint film is not random for many pigments. Even after a paint film is dry there is reason to believe that some diffusion of solid particles takes place. The arrangement of these pigment particles does influence color, chalking, hiding power and other properties in some cases. Changes in orientation or arrangement of pigment particles—and also vehicle or binder molecules—probably could be correlated with dielectric constant measurements. It is possible that these changes in dielectric properties are continuous and would be applicable to paints in service to determine the probable life span remaining. Perhaps these measurements could be applied with value to the paint before application.

I believe that failure is the culmination of a train of events that started when the paint was applied. This train of events is made up of chemical effects as the oxidation of organic vehicle is catalyzed by organic peroxides, metal ions and the photochemical action of ultra violet light; chemical reactions between pigment and vehicle components and other atmospheric agencies as moisture and CO₂; physical effects as the fatigue of long continued expansion and contraction with heat and moisture changes; the loss of volatile and soluble constituents from the film; the physical and chemical effects of the surface to which it is applied. These forces are continually at work. Exactly when and how the film fails will depend in many instances on accidental factors.

We wish we knew how the paint on one end of a panel can be perfect and the other very poor. Would one say that the unbroken paint film inside of a large alligator pattern had failed? Does it not probably show the same structure as that which made it check somewhere else?

Undoubtedly the biggest problem is developing methods for test that will be based on the internal structure of the film and not on the appearance of the film, the basis of judging used so widely today.

I believe that a film can have the structure that accompanies failure and yet, by a combination of circumstances favorable to it, not show apparent or visible failure for some time. Hence, exposure testing as a research tool is not very precise and is not able to make fine distinctions.

Question: What limitations do ceramic materials have in the chemical process industries, and what improvements are being made?

Answer: It may be said that in general ceramic materials are resistant to all strong acids with the exception of hydrofluoric acid. Mechanical properties limit the widespread use of ceramics. The principal problem in their application therefore is one of design against failure due to mechanical and thermal shock. New materials such as high fired porcelain, high silicon carbide bodies,

and ceramics armoured with resin impregnated glass cloth are successfully being used to counteract the thermal and mechanical shock difficulties.

Question: What methods are usable for the protection of steel piling in sea water installations? Particular interest — the offshore drilling rigs. Can steel piling be successfully cathodically protected?

Answer: The answer to this question has been covered in the May, 1950, issue of Corrosion Magazine, p. 161-166, summary of discussion "Corrosion and Protection of Offshore Drilling Rigs." Details regarding cathodic protection below low tide, Monel sheathing for the tidal zone, and protective coatings above the splash zone are summarized in this presentation. See also paper on the same subject in the June, 1950, issue of "Drilling," and CORROSION, 5,292-302 (1949) Sept.

A New Method for the Protection of Metals Against Pitting, Tuberculation and General Corrosion*

By H. LEWIS KAHLER* and CHARLES GEORGE**

Abstract

This paper presents a new principle in the field of corrosion for the control of tuberculation and pitting of metals in water-side corrosion. It is termed the dianodic method and employs a dual treatment of molecularly-dehydrated phosphates and chromates over selective pH ranges. Its use in relatively low concentrations gives benefits not obtainable with single treatments such as chromate, phosphate, etc. at considerably higher concentrations. Because it is able to eliminate the typical type of pitting and tuberculation that single chromate and single phosphate treatments cause when used in insufficient concentrations it is believed that this method presents a new approach in the field of corrosion. From the experimental evidence it appears that the two anodic treatments, phosphate and chromate, used together under the conditions of the dianodic method are not acting as two separate treatments but as a new single agency for the elimination of pitting and tuberculation. Pit reductions of 80-90% and more are not unusual to expect from this new method. Quantitative pit data are presented on specially-surfaced steel corrosion specimens accompanied by tuberculation data on the threads of pipe nipples. Plant results in recirculating cooling water systems so far indicate complete accord with the experimental data presented.

tion of 500 ppm is sufficient for the protection of ferrous parts of most equipment. In general application where the chromate has been limited to concentrations insufficient to stop total attack, the protection received has been inadequate and disadvantages such as tuberculation and pitting, and their attendant evils such as reduced water flow and perforation have to be tolerated.

Other inhibitors for the same type of water systems have been used such as low concentrations of phosphate and moderately high concentrations of chromate with or without acid treatment for con-

METALS, PARTICULARLY ferrous, corrode in water systems of all types causing loss of production and costly replacements. In order to reduce both of these, plant practice has been directed towards the use of many available corrosion inhibitors. For instance in closed engine jackets, radiant heating and open circulating water systems, present practice uses chromate concentrations as low as 200 ppm and as high as 10,000 ppm depending on the protection needed and the tolerable cost. Chromate has been used to reduce the rate of ferrous metal corrosion and is cited in references such as Evans¹ and Speller². Uhlig advises 500 ppm sodium chromate for old systems not previously inhibited, tapering off to 300 ppm after a reasonable period of time³. Rotheli and Cox have tested chromates on iron from 1,000 to 40,000 ppm, and the relation of chloride ion to the protection given⁴. They conclude on 14 day tests that "increasing the salt concentration or the temperature results in increasing the minimum concentration of retarder necessary for the protection of the metal. As suspected, insufficient concentrations of chromate tend to cause isolated attack and consequently pitting of varying degrees of severity." Darin⁵ who has had considerable experience in the practical application of chromates in industry, recommends its use in air conditioning, refrigerating brines, automobile systems, Diesel engines and cooling systems in the petroleum industry. He summarizes by stating that in general a moderate concentra-

* Submitted for publication April 11, 1950.

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trolling the alkalinity of the water. Usually the phosphate is the molecularly-dehydrated type (although orthophosphate can be used) and the concentration has been kept around 1-10 ppm range. Phosphates used like this are employed for the control of calcium carbonate scale formation. If the scale load is too high for the phosphate to carry, the alkalinity of the water is reduced by acid to a level where the phosphate is effective. Accompanying this phosphate is chromate usually in a concentration range up to 500-1000 ppm. The chromate in this scale-corrosion treatment is used to reduce the general corrosion which is present whether acid is employed for the alkalinity reduction or not. Ordinarily the pH advised for the chromate systems is in the range of 7-9.5⁸.

Corrosion claims have been made for phosphate treatments in the 1-10 ppm range by Partridge and Hatch⁶, Hatch⁷, Hatch and Rice⁸, and Rice⁹. Employment of sodium hexametaphosphate in steel systems has given conflicting results. Recent experiments by Hamer and Powell¹⁰ led them to believe that the action of sodium hexametaphosphate depends so much on the flow-rate and the amount of treatment added, and varies so much from one water to another that it is impossible to foretell its behavior in any given case, and it must be regarded as a somewhat unreliable inhibitor for general use. Pallo¹¹ reported that sodium hexametaphosphate at 2 ppm in a low-solids water gave higher steel losses than the untreated water at a flow rate of 0.05, 1.35 and 5.4 gallons per minute. Reduction of tuberculation was obtained along with resultant reduction of head losses.

Recently a phosphate treatment has been introduced wherein the molecularly-dehydrated phosphate is used in the range of 50 ppm, the pH of the water being adjusted below the point where calcium phosphate precipitation can take place. This treatment is relatively new and its performance has not been

generally demonstrated on a wide scale yet. One plant study has been published by Hosbach¹². He estimated 90% reduction in steel loss and some removal of old deposits.

Based on the authors findings, it is believed that the use of phosphate alone at about 50 ppm is seriously handicapped by its inability to save sufficient steel and to prevent severe pitting of metal. Concentration for concentration the role of phosphate as a steel saver is markedly inferior as compared to chromate. In regard to pitting, experience indicates that phosphate pits more viciously than chromate. In testing it had one slim advantage over chromate and that lies in the ability to reduce tuberculation somewhat but this advantage is offered at the sacrifice of steel saving and pitting. Modifications of this phosphate method have been advanced wherein other agents have been added to the phosphate to overcome its obvious shortcomings. Tests on these modified methods have shown that they offer questionable advantages over the phosphate alone.

The Dianodic Method for the Control of Pitting and Tuberculation

Chromates and phosphates used alone can afford steel saving to ferrous metals in contact with water. The amount and type of protection received is dependent on the conditions under which each is used. Both of these anodic inhibitors can cause considerable pitting and tuberculation if used in insufficient concentrations as already discussed. Chromate for instance is recommended by VanBrunt and Remscheid¹³ to be kept high (5,000 to 15,000 ppm) particularly if chlorides are high in concentration, otherwise cells with large cathodes and small anodes will cause intense attack. Evans¹⁴ states "given a sufficient concentration, these anodic inhibitors, 'chromates, phosphate, etc.' are efficient. Unfortunately they are dangerous since if added in insufficient quantities to stop attack altogether, the corrosion is severely localized and the intensity of attack enhanced so that perforation may occur more quickly than if no inhibitor had been added." The history of phosphate follows this same pattern in regard to pitting when concentration is under that level which will completely stop attack. Hamer and Powell¹⁵ consider that phosphates belong to the dangerous class of inhibitors likely to cause pitting when present in inadequate quantity.

Years of research were carried out by the authors on single anodic treatments including chromates, phosphate, silicates, nitrites, and many others under various conditions of pH, chloride and other anion concentrations, temperature and oxygen levels without leading to any outstanding improvements in pitting, tuberculation and general corrosion protection. This work led to the discovery that the two anodic inhibitors, phosphate and chromate, could be used together at the proper pH with the result that pitting and tuberculation were eliminated or greatly reduced. Since both corrosion inhibitors cause pitting and tuberculation with steel when used separately it was not obvious to place them together for the allevia-

tions of these ills, but that is the very basis for this new method. This method secures remarkable reduction in pitting tendencies at treatment concentrations only a fraction of those usually employed for phosphate and chromate when used separately. Remarkable treatment economy is secured in addition to the improved results.

It is altogether possible that the effect given by these two anodic inhibitors will open up a new field for the control of tuberculation and pitting which was heretofore thought impossible for low concentrations. It is not inconceivable that the idea can be extended to other combinations of inhibitors for the procurement of further relief from corrosion ills of various natures. Further work is being directed in these channels.

Experimental Work

Test Apparatus

In the experiments described here the apparatus was a continuous flow experimental water system divided into two sections, one section receiving the untreated water. This system therefore allowed the testing of one control and one treatment experiment simultaneously, or two control or two treatment experiments. Each section received the same tap water from the municipal water system of Philadelphia, Pennsylvania, at the desired temperature and oxygen content, and each section was supplied with additional ions and chemical additives by separate pumping and feeding systems. After the points of addition of the ions and chemicals, vessels were located for immersion of the corrosion specimens. The system allowed variation in the linear flow rate past the specimens from 0.02 to 2.5 feet per second. Three different types of plain carbon steel specimens were used; pipe and flat specimens to determine weight loss and for pit evaluation, and immersed pipe nipples for tuberculation studies on the threads. Specimens of copper-base alloys were also tested.

The flat specimens were high carbon steel having a composition of 0.9 percent carbon, 1.4 percent manganese, 0.04 percent sulfur, 0.3 percent silicon and no phosphorous. These specimens before exposure were resurfaced using a No. 80 grinding wheel to a machined finish of R.M.S. 20 microns to allow for accurate evaluation of pits. Before immersion the flat specimens were cleaned with tripoli (abrasive) followed by tri-sodium phosphate, alcohol rinse, dried and weighed. At 20 diameters the surface thus prepared was smooth without high polish, providing a good surface for counting pits and active areas. Ordinary hot or cold rolled low carbon steel surfaces were found to be too rough to permit quantitative evaluation of pitting although the initial work was performed with specimens of this type. Qualitative conclusions obtained in this manner, were in line with these later quantitative results.

The nipples of low carbon steel were prepared by degreasing and wire brushing the threads. The threads provided a very simple manner of studying tuberculation by visual examination after exposure.

The Philadelphia municipal water used had an average analysis of 40 ppm calcium as calcium car-

bonate, 20 ppm magnesium as calcium carbonate, 25 ppm alkalinity (methyl orange) as calcium carbonate, 28 ppm sulfate, 10 ppm chloride, 1 ppm silica and pH 6.6. In order to accelerate the corrosion, chloride was increased to a total of 500 ppm in the test water. The oxygen in the test water was kept at 5 ppm and the water temperature was regulated to 120 F.

The system was automatic and could be run under regulated conditions for long periods of time without supervision. The total water used for each experiment was metered so that experiments in which any large variation in flow resulted, due to interruption of the municipal water supply or to water flow from the water heating equipment, etc., could be disregarded.

After exposure the various specimens were subjected to microscopic inspection before and after cleaning. After cleaning the weight loss on the flat specimens was taken and the surfaces were examined for pits and active areas at 20 diameters magnification.

To aid in understanding the data presented, it should be noted that the characteristic chromate pits were mostly small, deep and aggressive, accompanied by large anodic areas, which were aggressive but not as deep. These anodic areas were found when examined under the microscope to be colonies of very small pits closely associated and shallow, and are herein referred to as "active areas." The phosphate pit formed by the phosphate treatment was a deep hole exhibiting little attack around the rim of the hole. Surface alterations allowed by the dianodic method were less aggressive and more shallow than those caused by chromate alone. In fact the surface alteration with this treatment was so slight that it did not truly belong in the pitting classification.

The molecularly-dehydrated phosphates presented in this paper are sodium tripolyphosphate, $\text{Na}_5\text{P}_3\text{O}_{10}$, sodium decaphosphate, $\text{Na}_{12}\text{P}_{10}\text{O}_{31}$, sodium hexameta-phosphate, $\text{Na}_6\text{P}_6\text{O}_{18}$, and sodium septaphosphate, $\text{Na}_7\text{P}_7\text{O}_{22}$. Orthophosphates were also tested including monosodium phosphate, disodium phosphate, trisodium phosphate and phosphoric acid. Sodium chromate and sodium dichromate were used to provide the chromate ion.

pH Limitation of the Dianodic Method

The make-up water requirements for most plants using large volumes of water are such that it becomes very costly to employ as much as 200 ppm of treatment. One of the great advantages of the dianodic method is that it permits operation with concentrations below 200 ppm while obtaining protection against general corrosion, pitting and tuberculation better than that previously obtained from chromate alone at considerably higher concentrations.

It is important to avoid precipitation of calcium phosphate by the reaction of complex phosphates or orthophosphates with calcium in the water under treatment, and therefore the pH of the water system should be kept below the pH of saturation of calcium phosphate. The pH of saturation of calcium phos-

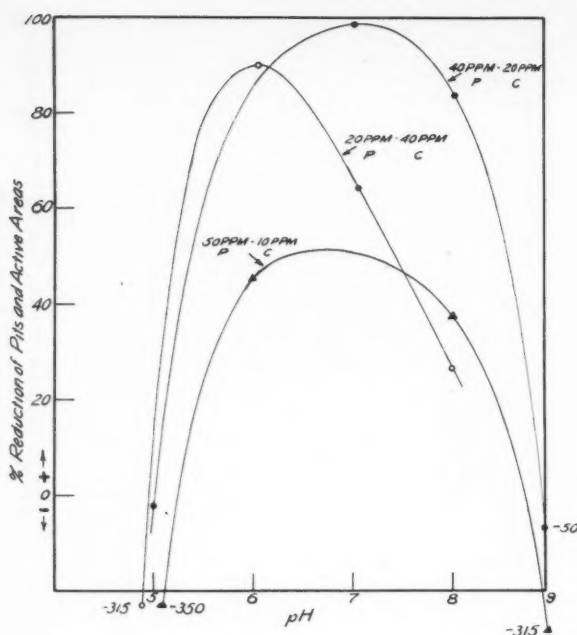


Figure 1—Effect of pH on the dianodic method-chromate basis.

phate for a given temperature, calcium and phosphate concentrations can be calculated from data similar to that published by Green and Holmes¹⁶.

Operating over the range of pH 5 to 9, the data plotted in Figure 1 were obtained comparing the percentage reduction in pits and active areas resulting from the dianodic method, as compared to the results from the same quantity of chromate. The water used was Philadelphia tap water with chlorides increased to 500 ppm, at 120 F, flowing at a rate of 0.36 feet per second, and having a corrosivity of 0.1 inch penetration per year without inhibitor. The tests extended for one and two days. The total quantity of treatment in each case was 60 ppm, the basis of comparison being 60 ppm of chromate alone, and each of the dianodic tests in Figure 1 involved a total concentration of 60 ppm. Thus over the pH range 6 to 8, less than an average 20 percent of the pits and active areas remain under this method compared to those resulting from the same concentration of chromate alone.

As pH 5 and pH 9 were approached the power to prevent pitting and active areas was lost and as will be noted from the ordinates below zero, it acquired a negative protective character harmfully increasing pitting to a very high degree at lower and higher pH levels. Thus the data indicated that pH 5.5 to pH 7.8 was the best pH range to prevent pitting and tuberculation.

When orthophosphates were used instead of molecularly-dehydrated phosphates, there was some loss in efficiency. Monosodium phosphate produced about one-third the reduction of pits and active areas as that obtained from molecularly-dehydrated phosphates. Mixtures of orthophosphates and molecularly-dehydrated phosphates, however, offered much of the advantage of molecularly-dehydrated phos-

phates out of proportion to the quantity of molecularly-dehydrated phosphates present. For example, in comparison with 60 ppm chromate, a mixture of 20 ppm of monosodium phosphate, 20 ppm of sodium decaphosphate and 20 ppm of sodium chromate, gave 95 percent as high in reduction in percentage of pits and active areas as did 40 ppm sodium decaphosphate and 20 ppm sodium chromate. The best results as compared to 60 ppm chromate alone were obtained from 40 ppm phosphate and 20 ppm chromate as far as pit reduction was concerned, and this composition gave the broadest pH plateau for high pit reduction when compared with chromate alone.

The results shown in Figure 1 indicate when compared to chromate alone, that the dianodic method gave excellent reduction in pits. At this level of concentration it was incapable of stopping total attack by this very corrosive water, but the relatively few pits that remained were shallow and seemingly non-aggressive. Before cleaning, the corrosion products were minute. Alteration of the character of the pit and tubercle is important, otherwise a reduction of pitting normally would lead to an intensification of attack because the metal would be lost over a smaller area. The dianodic method not only reduced the percentage of pits, but altered the nature of the attack on the steel so that it could hardly fall in the pitting classification because the affected areas had so little depth. As time progressed the attack became less active, suggestion that over a longer period of time the surface alteration would be healed. Observed under the authors conditions for pit depth measurement at 150 magnification, these areas left by the dianodic method gave no measurable depth. Correspondingly, pits in the specimens exposed to separate chromate and phosphate treatments were of the order of 0.1"/year and 1.0"/year penetrations respectively.

Whereas Figure 1 illustrates the effect of the dianodic method over various pH values as compared with chromate alone, Figure 2 gives the results as compared to 60 ppm phosphate alone over a similar pH range. Because molecularly-dehydrated and orthophosphates when used alone in these tests pitted the steel so viciously, the new method correspondingly exhibited a higher percentage reduction of pits and active areas. For example at pH 5, 6, 7 and 8, 60 ppm molecularly-dehydrated phosphate alone gave 6300, 11600, 5180 and 45 pits per square inch of surface respectively. Before cleaning, the phosphate pits had tubercles over them, but their height was not proportional to the depth of the pits as the phosphate treatment appeared to clean away part of each tubercle as it formed leaving less corrosion products than in the case of the chromate alone. The majority of the phosphate pits under the condition of test were deep enough to give a maximum penetration between 0.3 and 0.9 inch of steel per year. This is a tremendous penetration rate and would lead to failure by perforation in a short period of time.

It will be observed in Figure 2 that the dianodic method for 50 ppm sodium decaphosphate and 10 sodium chromate, 40 ppm phosphate and 20 ppm chromate and 20 ppm phosphate and 40 ppm chrom-

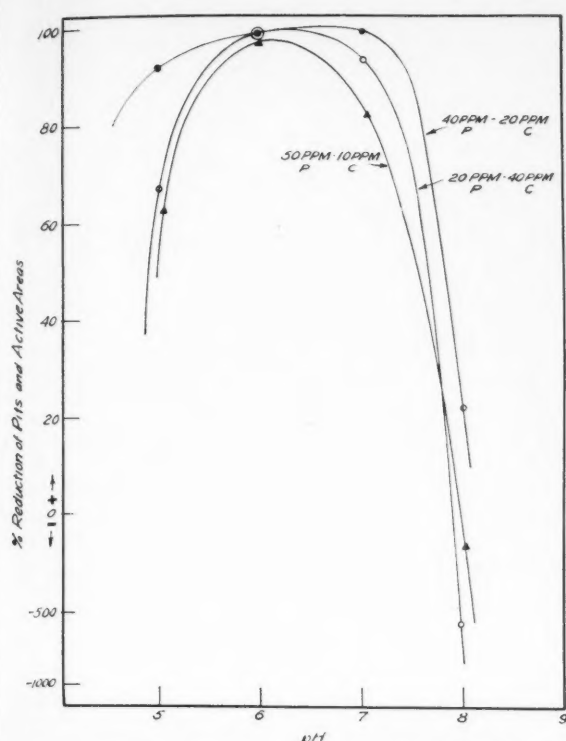


Figure 2—Effect of pH on the dianodic method-phosphate basis.

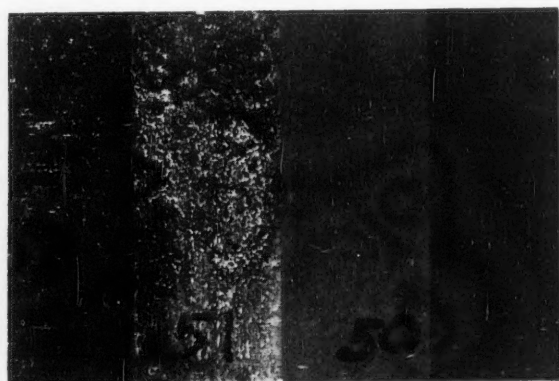


Figure 3—Chromate, phosphate and dianodic specimens compared to unexposed specimen.

ate in each case gave a big percentage of reduction of pits at pH 5, 6 and 7 (better than 90 percent) tapering off sharply at pH 8 and more slowly below pH 5.5.

Photographs of some of these results at two magnifications illustrate the relative frequency and type of the pitting tendencies of each of these treatments. Figure 3 shows specimen 53 which was exposed to 60 ppm chromate; the white dots indicate the pits that resulted. Specimen 51 used with 60 ppm sodium decaphosphate shows the intense pitting that was obtained. Specimen 50 which was exposed to the dianodic method (40 phosphate—20 chromate) gave little evidence of being attacked. The specimen at the extreme right was never exposed to water. It



Figure 4—Chromate pits at 18 magnifications.



Figure 5—Phosphate pits at 18 magnifications.

was resurfaced to 20 R.M.S. microns and subsequent cleaning by abrasive just the same as the other three specimens and is exhibited for comparative purposes.

To show the characteristics of the pits more advantageously, the above group of specimens were photographed at 18 magnifications. Figure 4 shows the pits resulting from 60 ppm chromate treatment and Figure 5 the ones resulting from 60 ppm phosphate treatment at pH 6. Even at this low magnification some idea can be gained of the depth of these phosphate pits from this one day exposure. Figure 6 shows a typical area of steel exposed to the dianodic

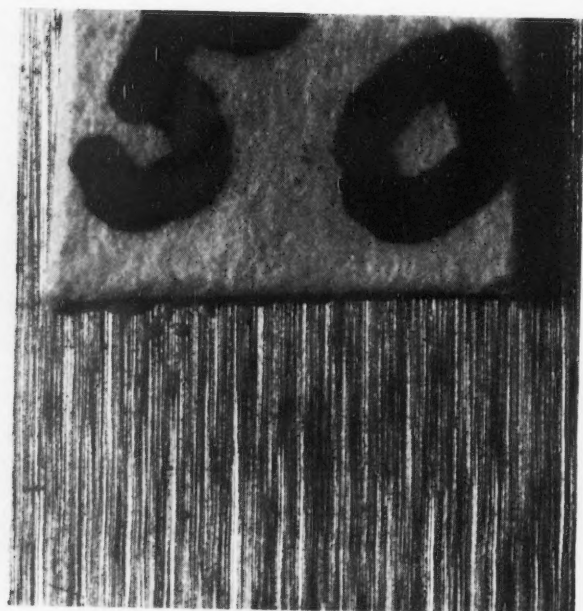


Figure 6—Dianodic method specimen at 18 magnifications.

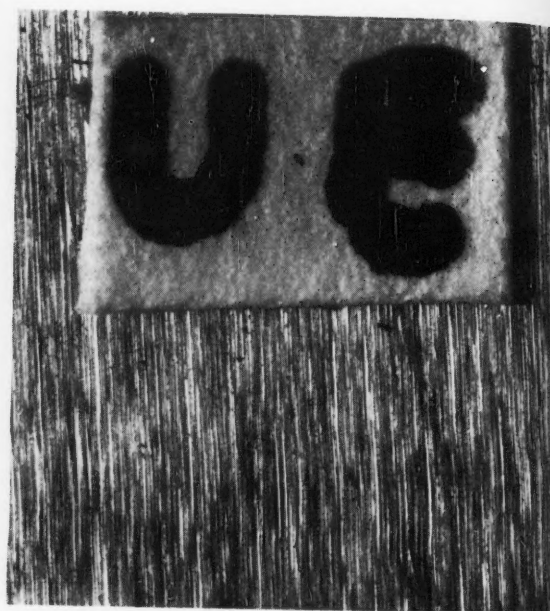


Figure 8—Unexposed specimen at 18 magnifications.

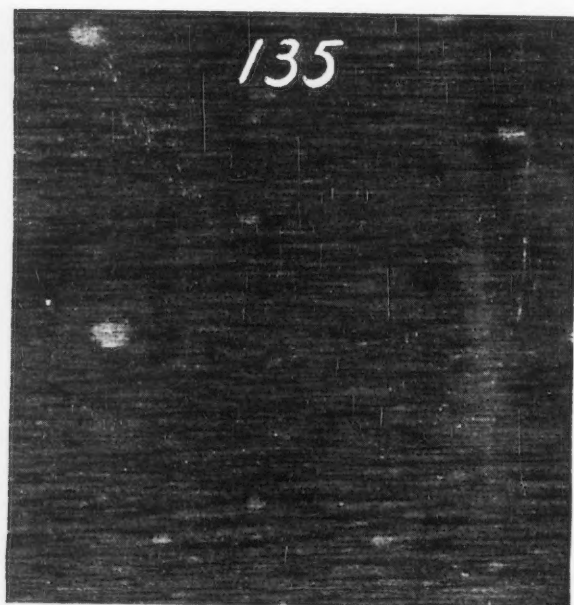


Figure 7—Shallow anodic areas from the dianodic method.

method using 40 phosphate—20 chromate at pH 6. What few surface alterations were present disturbed the surface so little that nothing is apparent at 18 magnifications. To demonstrate the few faint surface alterations photographs were made with the specimen turned 90 degrees. Figure 7 shows this result which indicates the elimination of all pits except a few large, shallow areas which barely registered on the photograph. These areas are typical and are offered as evidence that the method has the power to change the character of the pits that chromate and phosphate give when used separately. This

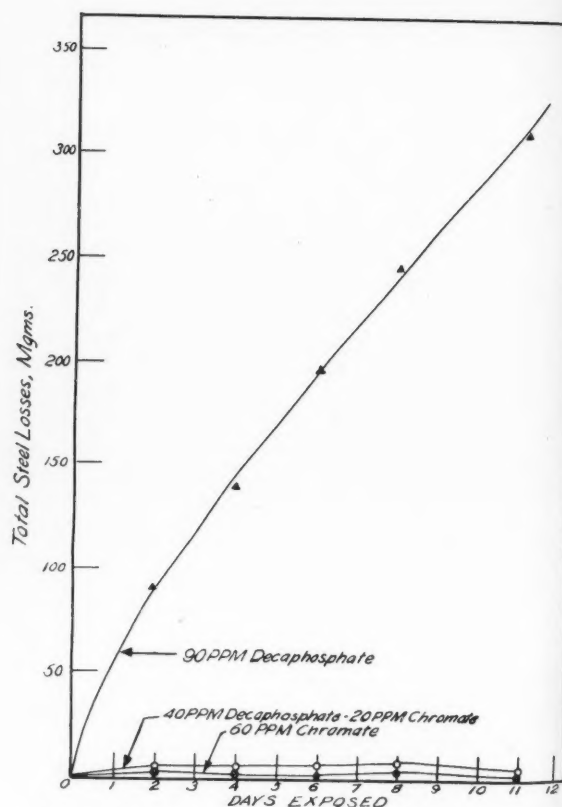


Figure 9—Dianodic methods also reduces general corrosion.

strongly indicates that the two anodic inhibitors chromate and phosphate are not acting as separate agents, but as a team combining their powers in some way not yet known to us to eliminate, or

greatly reduce pitting. If the two inhibitors were not acting in a new or different manner, the character of the pits remaining would be similar to either the phosphate or chromate type, or a possible combination of these types. But such is definitely not the case as borne out by repeated experimentation. Figure 8 is a section of surfaced steel unexposed to water. Comparison with Figure 6 shows that the dianodic method had done no damage to the surface, certainly nothing comparable to Figures 4 and 5 which treatments attacked the surface viciously.

Effectiveness of Dianodic Method Against Steel Loss as Compared to Chromate or Phosphate Single Treatments

The use of the combination of the two anodic treatments, phosphate and chromate in the advantageous pH range, to reduce tuberculation and pitting does not carry with it any disadvantages from the standpoint of controlling the loss of steel. Figure 9 shows that the dianodic method is as effective against loss of steel as the chromate treatment alone and far superior to the phosphate treatment alone. The curve for 40 ppm sodium decaphosphate and 20 ppm sodium chromate at pH 6 follows substantially the same pattern as the curve for 60 ppm sodium chromate, while the curve for 90 ppm sodium decaphosphate alone (the additional 30 ppm giving the phosphate alone an advantage in the comparison) slopes off only slightly in the first four days and after the fourth day assumes a straight line function corresponding to a high constant loss of steel with time.

Table I shows the same data as in Figure 9 for a continuous flow system using Philadelphia tap water at pH 6 to 7 with a flow rate of 0.36 feet per second and at 120 F. This table shows that the differential losses of the dianodic method were no higher than the chromate alone after the first day. The phosphate treatment alone, on the other hand, shows 30 to 50 times the steel losses of the other two treatments and these losses were apparently constant indicating that appreciably lower losses could not be expected as time goes on. Thus the dual treat-

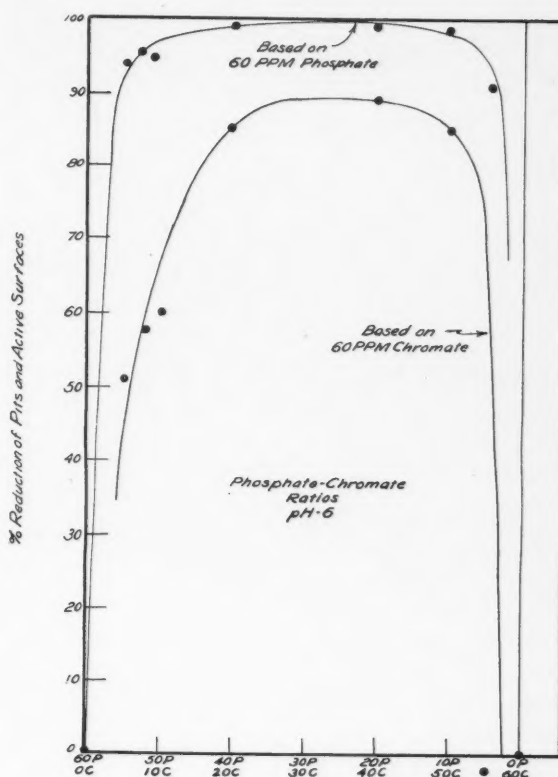


Figure 10—Concentration limitations of dianodic method pH 6.

ment has the power to save as much steel as the chromate treatment alone and nothing in the way of steel-saving power is sacrificed by using the combined treatment to obtain reduced pitting and tuberculation. A comparison of the calculated average penetration of these three treatments reveals deep penetration suffered by the phosphate treatment while chromate and the dianodic method gave low penetrations, both in the satisfactory range. The phosphate treatment over the eleven day period gave only 63 percent saving of steel compared to respective

TABLE I
Differential Losses of Three Corrosion Treatments

TREATMENT	Total Steel Losses Mgs.	Days Exposed	Differential Losses Mgs/Time	AVERAGE PENETRATION INCH PER YEAR	
				Based on Total Loss	Based on Loss From 8th to 11th Day
90 ppm Sodium Decaphosphate.....	90	2			
90 ppm Sodium Decaphosphate.....	139	4	49 mgs/2 days		
90 ppm Sodium Decaphosphate.....	198	6	59 mgs/2 days		
90 ppm Sodium Decaphosphate.....	247	8	49 mgs/2 days		
90 ppm Sodium Decaphosphate.....	306	11	59 mgs/3 days	0.026	0.019
60 ppm Sodium Chromate.....	1	2			
60 ppm Sodium Chromate.....	1	4	0 mgs/2 days		
60 ppm Sodium Chromate.....	1	6	0 mgs/2 days		
60 ppm Sodium Chromate.....	2	8	1 mgs/2 days		
60 ppm Sodium Chromate.....	2	11	0 mgs/3 days	0.00017	0.00032 (1)
Dianodic Method (2).....	5	2			
Dianodic Method.....	5	4	0 mgs/2 days		
Dianodic Method.....	6	6	1 mgs/2 days		
Dianodic Method.....	7	8	1 mgs/2 days		
Dianodic Method.....	4	11	0 mgs/3 days	0.00034	0.00032 (1)

(1) 1 mg. loss assumed in calculations even though zero loss was obtained.

(2) 40 Decaphosphate—20 Chromate.

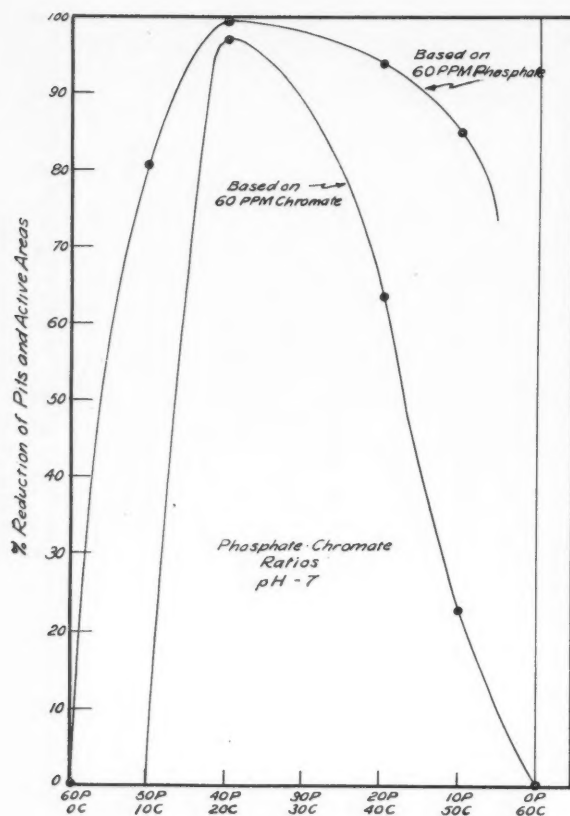


Figure 11—Concentration limitation of dianodic method pH 7.

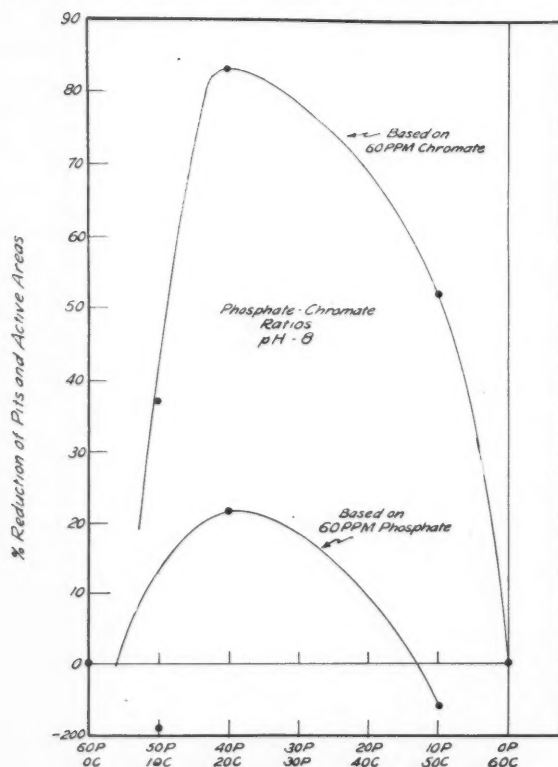


Figure 12—Concentration limitation of dianodic method pH 8.

savings by the chromate and the dianodic method of 99.6 and 99.4 percent.

Concentration Limitation of the Dianodic Method

As shown by Figures 10, 11 and 12, there are limitations imposed by concentration as well as those imposed by pH. Figure 10 plotted for pH shows that for 60 ppm of total treatment, the dianodic method at different ratios reduced pits and active areas very pronouncedly over phosphate and chromate alone, but the benefits dropped off markedly as the single ingredients were approached.

In Figure 11, plotted for pH 7, the treatment ratios of the dianodic method (based on chromate) were not as broad in the high percent reduction zone but broadened out at lower percentages. Again at pH 7 the effectiveness diminished sharply as the limiting concentrations of phosphate and chromate were approached.

Figure 12 plotted for pH 8, shows a breadth of improvement based on chromate alone which is almost like that of pH 7. The curve based on phosphate, however, shows less marked improvement, and the main advantage of the dianodic method is found in the center of the treatment-ratio region.

The results of Figures 10, 11 and 12 are obtained for 60 ppm of total treatment. Similar results may be obtained for other total treatments. For example, the work done at 40 ppm total treatment gave approximately the same results.

In the higher concentration ranges the following results are typical: At pH 6, 50 ppm of sodium decaphosphate—150 ppm of sodium chromate, 100 ppm of sodium decaphosphate—100 ppm of sodium chromate, and 150 ppm of sodium decaphosphate—50 ppm of sodium chromate gave respectively 61 percent, 68 percent and 89 percent reduction in pits and active areas compared with the results from 200 ppm sodium chromate alone. As compared with 200 ppm sodium decaphosphate alone, the respective reductions in pits and active areas were 92 percent, 94 percent and 98 percent. Corresponding reductions in tuberculation were obtained. The conditions of test were similar to those previously discussed in connection with Figures 1 and 2.

Thus at any concentration level, the curves prescribed show that satisfactory results can be obtained by employing the central portions of the treatment ratios listed. Where optimum results regardless of economy are important the highest total concentration should be used consistent with the conditions of the method. For many installations where economy is important along with good results, the dianodic method should employ less than 150 ppm total treatment. The best results consistent with maximum economy would employ around 50-75 ppm of total treatment. Naturally, the dianodic method in concentrations lower than 50 ppm can give better results at corrosion loads lower than 0.07 inch/year penetration and preferably with lower concentrations of anions. Thus the concentrations used should be fitted to the total corrosion load for the best results with

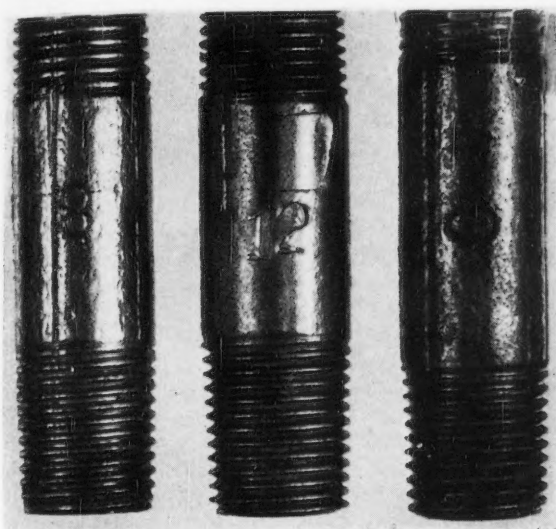


Figure 13—Tuberculation. Specimen 8—chromate; specimen 12—dianodic method; specimen 40—phosphate.

consideration being given to the chloride and sulfate concentrations.

Prevention of Tuberculation by the Dianodic Method

Low carbon steel nipples were exposed under conditions of Figures 1 and 2 at a water flow rate of 0.5 feet per second, providing an excellent opportunity to study the tuberculation phenomena in the threads. For example, using 40 ppm sodium decaphosphate and 20 ppm sodium chromate at pH 6, the nipple threads showed little or no rust products or tuberculations, and at pH 7 the results were almost as good, based on exposures of one and two days. At pH 8 it started to lose its power to keep the threads clean, and at pH 9 the protective power was completely lost and the threads were full of rust and large tubercles.

Comparing these results with Figure 1, it will be seen that the prevention of tuberculation was a function of pH as was the prevention of pits, which would be expected from theory since pitting causes tuberculation. Wherever there was a drastic reduction in the percentage of pits there was a corresponding reduction in the amount of tuberculation. At pH 5, 6, 7 and 8, the 40 ppm sodium decaphosphate and 20 ppm sodium chromate treatment over the same pH range. At pH 9 the dianodic method had nothing to offer over the chromate treatment alone. At pH below 6, the results were only slightly better than the chromate alone, indicating that the tuberculation protection was fading out, and at pH below 5 the tuberculation improvement over the chromate had been lost.

When compared with phosphate alone, the benefit in preventing tuberculation was not as marked as it was when compared with chromate alone, although the method maintained advantage over the phosphate which is most pronounced at pH 5.5 to 7.8. The tuberculation advantage is not as pronounced, it is

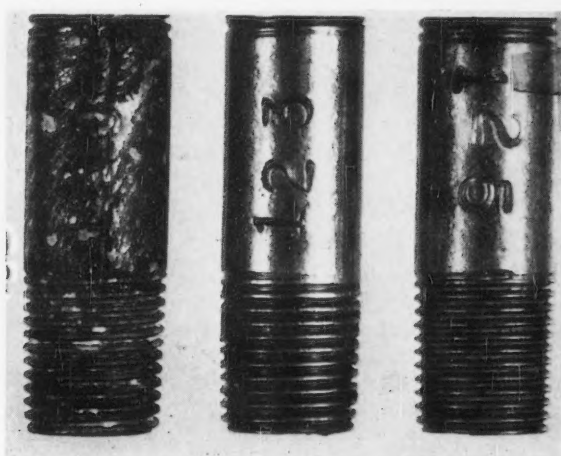


Figure 14—Tuberculation. Specimen 120—phosphate; specimen 123—chromate; specimen 125—dianodic method.

believed, because the phosphate when used alone is able to clean away some of the tuberculation formations from the pits it causes. At pH 8, the phosphate alone, like the dual treatment, begins to lose its power to clear away the corrosion products and tubercles. At pH 9 neither the phosphate alone nor the dianodic method prevented tubercles as the threads were full of rust and corrosion products. At pH 5.5 and 5.0 the prevention of tuberculation by phosphate alone was good and the other method had very little advantage over it from the standpoint of tuberculation. At pH below 5 the advantage of the new method was lost completely.

Some results on tuberculation are shown in Figures 13 and 14 taken at two magnifications. In Figure 13 the outside of specimens 8, 12 and 40 were exposed to 60 ppm sodium chromate, 60 ppm of the dianodic method (40 phosphate—20 chromate at pH 6) and 60 ppm sodium decaphosphate at pH 6 respectively. The threads of the chromate-treated one are full of rust inclusions and tuberculations while the threads exposed to the combination of inhibitors are clear of tubercles and products. The specimen exposed to the phosphate treatment was free of large tubercles but had many small ones along with some iron oxides. After exposure the bodies of the nipples were comparable to the threads in each case, but the plastic spray used to preserve the specimens caused considerable reflections and highlights in the photographs so that comparison of tubercles and products on the nipple bodies is not possible. In Figure 14, the outside surfaces of specimens 120, 123 and 125 were exposed to 200 ppm sodium decaphosphate, 200 ppm of sodium chromate and 200 ppm of the dianodic method (150 phosphate and 50 chromate) at pH 6 respectively. The heavy fine iron oxide coating on the phosphate specimen (120) made it appear unsprayed. At this level of concentration the phosphate did not eliminate all the big tubercles, and left considerable smaller ones. The chromate specimen (123) again gave threads full of rust inclusions and tubercles. Specimen 125 was free from tubercles and corrosion products in general. These tubercula-

tion studies were carried out at 0.5 ft./second water flow past the external surface of the specimens but the actual flow between the threads was much lower. This low rate of flow between the threads imposed a difficult load on each inhibitor. That the dianodic method was able to prevent tuberculation and rust inclusions shows that it possesses powers far beyond those of the single inhibitors.

Plant Results

This new method has very recently been applied in plant practice with gratifying results. Plant personnel report a satisfactory reduction in the replacement of pipe and equipment, and observation of equipment and water flows indicates reduced pitting and tuberculation over any single treatment tried. Twenty or more plants have now installed this treatment. These plants have been selected so as to provide different types of waters and operating conditions in order to determine the versatility of this new method under different types of corrosion loads.

Theory of Action of the Dianodic Method

It is difficult on the basis of the data accumulated thus far to formulate a theory for the marked improvement obtained by using chromate and phosphate together under the conditions of the Dianodic method. The following explanation would appear to be supported by the results thus far obtained. The method cleans away corrosion products from the surface of the metal as they form. By thus removing corrosion products, the method permits the chromate to maintain constant contact with all surfaces, and maintain protection. Because the new method eliminates both the chromate and phosphate types of pits by changing their character, it is possible that the two anodic inhibitors exhibit a different mechanism when used together than when used alone. The authors hope to gain further insight in this conjoint behavior as experience widens.

Conclusions

1. The combination of two anodic inhibitors, phosphate and chromate, under the proper concentration and pH has been shown to control pitting and tuberculation of steel and copper base alloys in water systems which each single treatment is unable to stop even in much higher concentrations.
2. Although the two inhibitors work to effectively

control pitting and tuberculation, the combination loses none of its effectiveness in controlling general corrosion of metals, equalling protection by chromate alone and being far superior to phosphate treatment at controlled pH.

3. This new corrosion method is believed to have power other than that derived from the single functions of phosphate and chromate; it is believed that the conjoint behavior in eliminating the chromate and phosphate types of pits indicates a new function. It is altogether possible that this combination of treatment might open new vistas in the inhibitor field and provide freedom from pitting and tuberculation which has heretofore been believed impossible with low concentrations.
4. Results in more than 20 plants using diversified waters and conditions have shown reduction of pitting and tuberculation along with good control of general corrosion. Plants are reporting equipment replacement has been greatly reduced by as little as 30 ppm of total treatment over a 10 months period.

References

1. U. R. Evans, *Metallic Corrosion, Passivity and Protection*, New York, Longmans, Green & Co., 557, 535 (1946).
2. Speller, *Corrosion, Causes and Prevention*, McGraw Hill Publishing Co., 381 (1935).
3. Uhlig, *Corrosion Handbook*, John Wiley & Sons, Inc., 499 (1948).
4. Roetheli and Cox, *Ind. and Eng. Chem.* **23**, 1084 (1931).
5. Darrin, *Ind. and Eng. Chem.* **37**, 741 (1945).
6. Partridge and Hatch, *Proc. Amer. Society Testing Material*, **40**, 1333 (1940).
7. Hatch, *J. American Water Works Association*, **33**, 1179 (1941).
8. Hatch and Rice, *Ind. Eng. Chem.*, **31**, 51 (1939).
9. Rice, *J. Amer. Water Works Association*, **34**, 1454 (1942).
10. Hamer and Powell, Private Communications to U. R. Evans, Refer to Page 326 in "Metallic Corrosion, Passivity and Protection," U. R. Evans.
11. Pallo, *J. Amer. Water Works Association*, **38**, 499-510 (1945).
12. Hosbach, E. C., *Proc. Midwest Power Conference*, 314 (1949).
13. VanBrunt and Remscheid, *Gen. Electric Rev.*, **39**, 128 (1936).
14. Evans, *Metallic Corrosion, Passivity and Protection*, 535 (1946).
15. Hamer and Powell, Private Communications to U. R. Evans, Refer to page 326 in *Metallic Corrosion, Passivity and Protection*, U. R. Evans.
16. Green and Holmes, *J. Amer. Water Works Association*, **39**, 1090 (1947).

Surface Potential Method of Corrosion Survey of Pipelines*

By O. W. WADE*

TO DATE THERE have been numerous methods used in making corrosion surveys for the location of cathodic protection units and as a source of information to aid in estimating the cost for cathodic protection. This paper will present some of the merits of the surface potential method of corrosion survey. The theory and application of this method has been well presented by O. C. Mudd.¹

This type of corrosion survey can be done with the minimum amount of equipment and can be easily taught to field personnel. The equipment necessary for this survey consists of a high-resistant voltmeter (zero-center), two copper sulfate half-cells, one 100-foot test lead wire, one pipe locating rod, one pipe contact rod and an electronic pipe locator. One technician and two helpers will suffice for the necessary personnel. The crew of three, thus equipped, should cover from two to three miles in eight hours, depending on the type of terrain.

The Great Lakes Pipe Line Company has surveyed well over one hundred miles of lines in different localities. The line currents (millivolt drop across one hundred feet of line), soil resistivity every fifty feet, surface potential every hundred feet and actual pipe-to-soil potential (Cu-Cu-SO₄ reference) every 500 to 600 feet have been recorded. A study of all these data revealed that the prime consideration for the location of anodic areas was the pipe-to-soil potential calculated from surface potential observations. The rest of the data obtained merely substantiated the information offered by the surface potentials alone.

A record has been kept of all leaks that have occurred since the original construction of each line. At the beginning of the corrosion mitigation program, these records were referred to for locations of areas that would be cathodically protected. Following a plan for spot protection, each area was checked for soil resistivity and the line current was measured by millivolt drop across 100 feet of line every 200 feet. The extent of this type of survey was determined by the results of the readings. It was soon learned that the line current could not be accurately determined by observing the millivolt drop across a 100-foot section of line because of the difference in cross sectional area of the pipe due to reconditioning. The potential drop across the same area was observed before and after the installation

Abstract

The techniques of surface potential methods for corrosion surveys on pipe lines will be reviewed. Instruments for the survey must be suitable for use by field personnel. The economics of conducting complete corrosion surveys on bare pipe lines are discussed. The economic aspects for determining location of galvanic anode installations versus regularly spaced installations will also be presented.

of anodes to obtain some idea of the amount of current that was being taken off.

Magnesium anodes were installed in soil of the lowest resistivity for the area and were tied to the pipe line any place convenient to the installation. It was observed that some of these installations had little if any effect on the pipe-to-soil potential, or in decreasing the line current. Millivolt drop readings taken below the anode installation indicated that current was being added to the line rather than taken off.

This method of installing anodes was regarded as uneconomical and a more efficient method was desired. A thorough study of Mr. Mudd's work presented what was considered a practical approach to the solution of the survey problem. It was decided that some experimenting with the surface-potential method of corrosion survey should be done. If more promising results were not obtained by this approach, the practice of regularly-spaced installations would be adopted.

Short surveys were taken over areas located from break-leak reports. These short surveys made it easy to locate the spots where leaks had occurred. When locating repaired breaks from the survey station given by the break-leak reports, it was often found that chaining or measurements were in error with the information referred to. The surface-potential survey was found to be extremely accurate in determining the exact location of previous breaks. Leak repairs were found to substantiate the locations.

In recording the corrosion survey data, pipe-to-soil potentials are shown to be more negative upward. The most negative potentials form a peak in the plotted curves and will be referred to as "peaks." The short surveys taken across an area where a previous break was known to have occurred, usually showed peaks other than those at the previous break. Each of these peaks indicate an anodic spot—a location for a future anode installation.

When making a surface potential survey, potential drops are taken across 100 feet of soil over the pipe line. When a peak is observed it is usually necessary

* A paper presented at the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.
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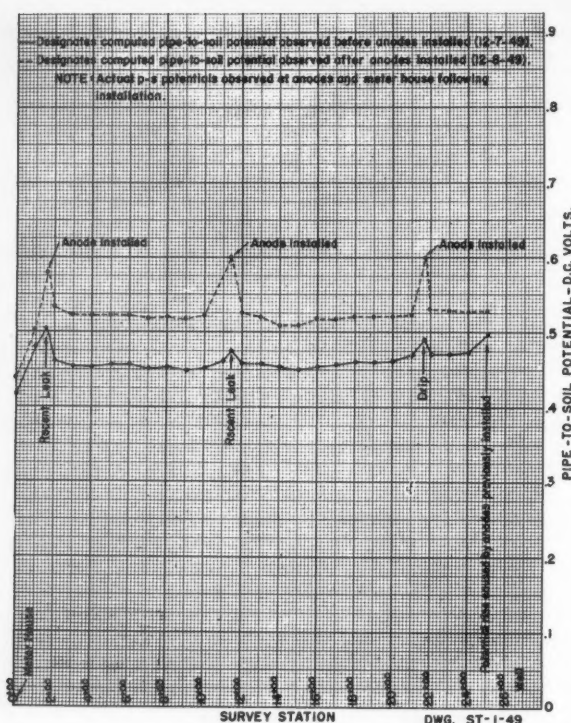


Figure 1—Corrosion survey on 4 inch well line. Sec. 16-31-39 Morton County, Kansas.

to take the potential drop across shorter increments on each side of the peak to locate the point of greatest negative pipe-to-soil potential or highest peak. It may be necessary for the increments to be as small as twelve inches.

Consider a local cell of an existing pipe line. The current is leaving the pipe at the anode portion of the line and is collected on the cathode portion of the line. If a galvanic anode installation is connected to the line at the exact spot where the local cell current is leaving the line, it should offer a lower resistant drainage path for the current and add to the current of the local cell. If the installation is connected to the pipe in the cathodic area, the impressed current will be opposing the current from the local cell and more energy will be required to suppress this local action. Also, the current from the galvanic anodes will be concentrated in an area that has been afforded some protection from local cell current. With the anode installation located at the most anodic spot on the line for any particular area, the impressed protective current is concentrated on the area where it is needed.

Upon locating the maximum peak, the line is uncovered and contact lead wires are installed. The line is then recovered with about 12 inches of dirt. Using two Cu-Cu-SO₄ electrodes, one is placed about four inches from the line on the side opposite the anode installation. The other electrode is placed about 24 inches from this electrode away and perpendicular to the pipe line. The potential drop between these electrodes is relative. The polarity will indicate that the current is flowing away from the line. Anodes

are added to the installation at this spot until the potential drop between the Cu-Cu-SO₄ electrode is zero or is reduced to a minimum.

The installation of anodes by this method requires that the anode back-fill be of the type that will soak quickly and allow the anode to produce its maximum current out-put as soon as possible. This can be easily done when the back-fill is mixed in the hole. The back-fill in some of the packaged anodes is slow in absorbing water.

This method of corrosion survey and anode installation was used on a 4-inch line in Morton County, Kansas (see Figure 1). The data obtained from the corrosion survey located two spots where leaks had occurred and had been repaired, and one "sweat" that was not known to exist. It was found that one 17 pound magnesium anode installed at these locations supplied enough current to suppress the local current that was leaving the line at these locations. A study of the computed pipe-to-soil potentials, before and after the installation of anodes, will show slight peaks in the plotted curve at stations 5 plus 00, 8 plus 00, and 18 plus 00 in addition to the locations mentioned before. These peaks, though small, should be considered as necessary locations for additional anode installations. The results obtained with the three 17-pound magnesium anodes installed would indicate that one anode installed at these three additional locations would be sufficient to suppress the local cell current leaving the line. Assuming this to be true, six 17-pound magnesium anodes would be required to suppress all measurable local cell current.

Where existing bare lines are being considered for reconditioning and application of cathodic protection, a surface potential corrosion survey of the entire line would be the most economical approach. This survey will locate the areas which require reconditioning as well as the exact location for the installation of galvanic anodes.

In the past it has been the practice of pipe line owners to recondition those areas where leaks have occurred; or uncover suspicious sections and make a visual inspection to determine whether reconditioning is required. It is quite probable, where a surface potential corrosion survey of an entire line is made, that leaks or potential leaks will be located where none have previously occurred. The location and reconditioning of these areas before the cost of property damage and loss of products have been added can be readily appreciated.

The author's company made a surface potential corrosion survey of a five mile section of a 4-inch products line which was isolated by insulating flanges at each end. The locations for the galvanic anodes were determined and a crew of men was sent out to make the installations. At one location, when the line was uncovered for the installation of the contact wire for the galvanic anodes, gasoline fumes were noticed. The hole was "flashed" and one of the men proceeded to clean the pipe so the wire could be "Cadwelded" to the line. Upon removing the heavy scale, a leak broke out. In one hour and twenty minutes, the line was "shut down," temporary repairs made and put

back into service. Approximately five barrels of gaso-line were lost and no property damage was incurred. Checking the leak records, no leak had previously occurred in this area.

Conclusions

Surface potential surveys are very useful to determine the extent of external corrosion that prevails on existing bare pipe lines. The data thus obtained may be used for determining: (1) the exact amount of pipe footage that should be reconditioned, and (2) the optimum location for installing expendable anodes. On coated pipe lines, surface potential surveys are valuable for locating imperfections in the protective coating.

While the actual field survey may be performed by nontechnical personnel, it is necessary that the data obtained in the field be interpreted by an experienced corrosion engineer.

Reference

1. O. C. Mudd, "Control of Pipe-Line Corrosion," *Corrosion*, 1, No. 4, 192-218 (1945) December and *Corrosion*, 2, No. 1, 20-58 (1946) March.

DISCUSSION

By O. C. Mudd, Shell Pipe Line Corp., Shell Bldg., Houston, Texas.

The paper presented by Mr. Wade gives some excellent examples of corrosion detection through surface potential measurements.

The existence of such surface potentials are from electro-chemical reactions following those basic science laws discovered years ago by Helmholtz, Ohm, Farady and others. The basic principles are that any corroding metal establishes an electrical voltage difference between the metal and solution or soil and the current flow produced depends upon the resist-

ance encountered in the current paths. Since the average pipe metal has a resistance over appreciable lengths of only a small fraction of the soil or water adjacent to the pipe metal it is obvious that soil resistivity controls the amount of current flow under any existing potential.

From the above it can be understood that higher potential differences along pipe in high resistivity soils results in a lower corrosion rate, however, corrosion must exist to establish a potential.

It has been found that potential nodes or peaks may be temporary depending upon change of soil moisture and disappear during dry weather. The annual corrosion rate of such spots is reduced.

Measurements of potential difference between a point adjacent to the pipe and another more remote on the side opposite the galvanic anodes during installation may require deviation at times by moving the electrodes along the line away from an anode installation, especially when several anodes are grouped close to the pipe because the current flow from these anodes through soil below pipe depth may cause potential gradients that increase those previously measured as originating from the pipe anode surface. In such cases it is advisable to move the potential electrodes a short distance beyond the proposed galvanic anode installation extremities remaining on the opposite side of the line and install sufficient galvanic anode to show definite current flow from soil to pipe.

The use of inexperienced personnel for surface potential measurements is not concurred with because experienced personnel can interpret readings when they are taken and thus detect many corroding spots that may be missed by others.

Surface potential measurements have many unexplored possibilities and corrosion engineers should investigate every channel of these measurements that promise simpler and more rapid accomplishment of their work.

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Halides as Acid Pickling Inhibitors*

By KARL F. HAGER* and MORRIS ROSENTHAL**

IN INDUSTRIAL PLANTS acid pickling inhibitors are chiefly organic compounds consisting of a hydrocarbon part attached to an ionizable or polar group. Generally, they contain nitrogen, oxygen, sulfur, or other elements in the fifth and sixth groups of the Periodic Table.

A new group of simple inorganic acid pickling inhibitors, whose industrial importance is doubtful at present, due to their cost, consists of the halogens and the halides. This group of inorganic inhibitors employs a mechanism of metal protection far different from the usual inorganic inhibitors, which are almost all salts of metals (such as arsenic and antimony) which are nobler than iron. The chief interest in the use of halides as inhibitors is because previously they were thought to be accelerators of acid attack against metals.¹

Investigations conducted at this laboratory in order to observe the mechanism of retardation and acceleration of acid pickling by the addition of various compounds led to the discovery that the halogens and the halides had a pronounced effect upon the acid attack against ferrous metals. It is reported widely that halogen ions, particularly chloride ions, are destructive to passivity and usually should be avoided whenever it is essential that passivity be retained.²

The inhibition of the acid attack on the basis metal was found to increase with the increase in atomic weight of the halogen in the molecule. The rate of oxide removal from the rusted ferrous metal surface was not noticeably affected regardless of the halide used.

In brief, iodine and iodides were found to be excellent inhibitors in concentrations of 0.1 percent and over, bromine and bromides were next in effectiveness, chlorine and chlorides were also inhibitors, but fluorine and fluorides were accelerators of acid attack on the basic metal. The halide part of the salts (the anion) was found to be the active inhibiting ingredient because regardless of the cation in the salt molecule (so long as it was less noble than iron), or lack of cation in the case of the pure halogen, the results within limits of experimental error were of the same magnitude.

Only inorganic salts were employed in the tests herein reported, and the field of investigation is now open to experimentation with the organic halides and the halide salts of organic compounds that are

Abstract

Acid pickling inhibitors used in industrial plants are generally organic compounds consisting of a hydrocarbon part coupled to a ionizable or polar group. A new group of inorganic inhibitors whose industrial performance is not proven, because of its cost, consists of halogens and halides.

Investigations were conducted in order to observe the mechanism of retardation and acceleration of acid pickling by the addition of compounds to determine the effect of halogens and halides on the acid attack against ferrous metals. Inhibition of acid attack on base metal was found to increase with the increase in atomic weight of the halogen in the molecules. The rate of oxide removal on rusted ferrous metal surfaces was not noticeably affected regardless of the halide used. Iodine and iodides were found to be effective inhibitors in concentrations of 0.1 percent and over. Bromine and bromides were next in effectiveness, and chlorine and chlorides were also inhibitors, but fluorine and fluorides were accelerators of acid attack on base metal. The halide part of the salt (the anion) was found to be the active component because, regardless of the cation used less noble than iron, results within limits of experimental error were of the same magnitude.

The theory of halide inhibition of iron dissolution may be in the formation of a passivating monomolecular film of the iron halide. Mild steel (SAE 1010) pieces were used as material for test specimens, so that acid attack on clean, polished, unoxidized steel could be determined. Tests were made in pickling solutions of 1 and 5 normal sulfuric acid and 5 percent nitric acid using varying concentrations of inhibitors and several different temperatures for a number of test durations. These tests show that further research and study on the use of halides as pickling inhibitors is warranted. Iodides, having excellent inhibitor properties, may not be adequately efficient in the concentrations that commercial inhibitors are employed but may be satisfactory in combinations with various compounds as acid pickling inhibitors. The study of the mechanism of halide passivation disputes the belief they are accelerators of acid attack.

soluble or colloiddally dispersed in pickling acid solutions.

Theory

Normally, inorganic pickling inhibitors are almost all salts of metals which have a comparatively high hydrogen overvoltage. These metals are plated on the iron, forming a fairly continuous film over the metal surface. These plated metals are cathodic and are charged negatively to the iron. In the electrolytic cell formed by this iron-to-nobler-metal couple, the high hydrogen overvoltage of the deposited metal prevents the discharge of the hydrogen ions. This hydrogen polarization of the negatively charged area (cathode) also stops the reaction at the positively charged area (anode) and the dissolution of the ions is prevented.

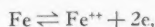
In the case of the halide inhibition of the dissolution of iron, the explanation may be in the formation of a passivating monomolecular film of the iron

* Submitted for publication May 12, 1950.

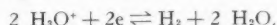
* Department of the Army, Ordnance Guided Missile Center, Redstone Arsenal, Huntsville, Alabama.

** Universal Engineering & Chemical Consultants, El Paso, Texas.

halide. This film, it has been found³ causes an increase in the change of overvoltage polarization potential both in the anodic reaction,



and particularly in the cathodic reaction,



Evidence here shows that the dissolution of iron is not entirely "cathodically controlled" but is primarily cathodic control supplemented by repression of the anodic reaction by the halogen. Iofa and Medvedeva³ show that for 1-N sulfuric acid solutions the cathodic polarization potential is -410 mv., whereas for 1-N HBr the cathodic polarization potential is -485 mv., and for 1-N H_2SO_4 plus 0.2-N KI it is -540 mv. As the concentration of the sulfuric acid is increased, the variation of the cathodic polarization potential between the uninhibited and the halide inhibited acids becomes greater, but the variation of the anodic polarization potentials between the uninhibited and inhibited pickling acids becomes smaller.

The type of passivating effect observed would seem to be due to the halide ion making the iron's electrochemical behavior become that of a nobler or considerably less active metal because the increases in polarization are appreciable.

Experimental Tests and Results

Mild steel (SAE 1010) pieces were used as the material for the test specimens, so that the acid attack on the clean, polished, unoxidized steel could be determined.

The pieces were cut to give areas of 27—29 cm², and then were ground to a uniform thickness of 0.035 inches. After a degreasing process in a boiling alkali-soap solution in water, the specimens were rinsed with distilled water, then with a warm 75 percent methanol solution (pH value of 7—8), dried, weighed, and used.

The pickling baths consisted of 600 ml. beakers containing 400 ml. of the pickling solution to be tested. The steel pieces were suspended in the pickling bath by means of glass hooks. All beakers were fitted with glass covers which permitted a small amount of ventilation. The tests were conducted at special and at ambient temperatures (21° C to 25° C).

The first series of tests was made with 1-N sulfuric acid as the pickling medium because this acid is

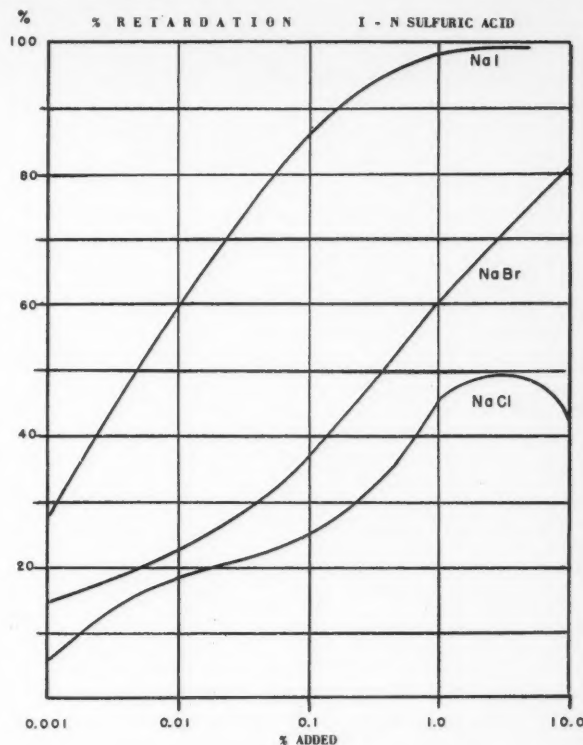


Figure 1

most frequently used in acid pickling. Figure 1 gives the results obtained from standard 48-hour pickling tests employing three halides at eight different concentrations. The fourth halide, fluoride, was found to accelerate (or not affect at best) the acid attack.

In order to further explore the halide effect, other halogen-containing inorganic compounds were tested in the same manner and some of the results are indicated in Table I where 0.1 percent concentrations of the compounds under test were added to the 1-N sulfuric acid.

The lower inhibition of the pure iodine as compared to the iodides is due to the small solubility of the iodine in the pickling acid. After the high initial attack rate of the acid against the iron, more of the iodine enters into solution as the iodide and then the attack is retarded or inhibited by the iodide.

Because commercial evaluation is on a weight basis, the weight percent concentration of the different halides was kept on a comparative basis, whereas the percent halogen by weight which is of theoretical interest was not on a comparative basis.

It was found that as long as no side-reactions (as could be obtained by using an oxidizing or reducing agent) occurred, the percent retardation was based on the percent halogen by weight regardless of the cation employed that was less noble than iron. The halides incorporated in oxidizing agents, on a percent halogen by weight basis, are found to possess the inhibitor properties of the halides alone plus the inhibitor properties obtained from the oxidizing properties of the compounds or from secondary reaction products.

In order to increase the speed of pickling it is usual practice to increase the pickling acid concen-

TABLE I
Halide Inhibition in 0.1% Concentrations

Inhibitor Added	% Halogen by Weight	Weight Loss mg/cm ²	Rate of Loss mg/cm ² /hr.	Retardation Percent
Control.....	28.2	0.588
NaCl.....	0.061	22.8	0.475	19.2
NaClO ₃	0.033	23.2	0.483	17.9
NaClO ₄	0.029	23.2	0.483	17.9
HCl.....	0.097	18.9	0.394	33.0
Ca(OCl) ₂	0.050	18.8	0.392	33.3
NaBr.....	0.078	17.9	0.373	36.6
NaBrO ₃	0.053	16.1	0.335	43.0
HBr.....	0.099	16.5	0.344	41.5
Br ₂	0.10	16.3	0.340	42.2
NaI.....	0.085	4.8	0.085	85.6
NaIO ₃	0.064	6.18	0.129	78.1
NaIO ₄	0.059	6.4	0.133	77.4
HI.....	0.099	2.56	0.053	91.0
I ₂	0.10	6.15	0.128	78.2

tration. Because this is the commonest case, determinations of retardation were made at various times on test pieces immersed in 5-N sulfuric acid at 70° F. Pieces, after being used, were discarded because the protective film was disturbed and duplication of results was made more uncertain. Pickling tests of two hours were run with the following results:

These tests compare favorably with results after 20 and 96 hours which give the following representative results:

The effect of time upon the inhibition can be seen

TABLE II
Two-Hour Test in 5-N Sulfuric Acid

Inhibitor	Concentration	% Retardation
NaI	0.0125 %	90 %
NaI	0.025 %	96 %
NaI	0.125 %	98 %
NaI	0.5 %	99.9 %
HI	1.1 %	99.9 %
NaBr	0.09 %	48 %
NaBr	0.5 %	89 %
NaBr	0.9 %	89 %
NaCl	0.05 %	27 %
NaCl	0.1 %	40 %
NaCl	0.5 %	57 %
NaCl	1.0 %	67 %
NaCl	10.0 %	66 %
NaCl	20.0 %	38 %

to be negligible in the case of the iodides, but in the case of the chlorides and bromides there is a slight drop in inhibiting properties from the start until 20

TABLE III
Inhibition in 5-N Sulfuric Acid

Inhibitor	Concentration Weight %	After 20 Hours		After 96 Hours	
		Loss mg/cm ² /hr.	Retard. %	Loss mg/cm ² /hr.	Retard. %
Control	..	1.605	1.410
NaCl	1.0	0.630	60.2	0.404	71.3
NaBr	0.5	0.326	79.7	0.1675	88.1
NaI	0.5	0.0203	98.7	0.0115	99.2
NaI	0.1	0.0345	97.8	0.0158	98.9

hours, from which time on the retardation begins to increase.

Halide atoms bound to oxidizing agents also exhibit a rise in inhibiting properties (expressed as percent retardation) as the acid concentration increases provided no secondary reactions occur which are detrimental.

Tests with halides in the inhibition of sulfuric acid attack on metals at elevated temperatures show that just as increasing the acid concentration increases the percent retardation of the halides, so does elevating

TABLE IV
Inhibition After 26 Hours in 5-N Sulfuric Acid

Inhibitor	Concentration	% Retardation
NaClO ₃	0.1 %	42 %
NaPrO ₃	0.1 %	64 %
NaIO ₃	0.1 %	84 %
NaClO ₄	0.1 %	1.6 %

the temperature. After 90 minutes at 150°F. an addition of 0.1 percent sodium iodide to 1-N sulfuric acid inhibiting the attack on mild steel SAE 1010 by 96 percent.

In the case of hydrochloric acid pickling only the

iodides were acid attack inhibitors. Concentrations of chlorides and bromides up to 1 percent gave no inhibition. Iodides, however, represented by sodium iodide yielded the following at 75° F.:

% wt. concentration	% retardation
0.0125	20
0.025	27
0.25	83
1.3	94

The acid concentration was 19 percent HCl by weight and the test periods were for 1 and 2 hours, the results being about equal for both time intervals.

When 5 percent nitric acid was employed at 75° F. for four hours, it was found that the halides of metals less noble than iron were inhibitors as Table V indicates.

The iodides were also effective in 10 percent nitric acid, where the retardation exhibited by 0.1 percent NaI was 87 percent after two hours. As before, the chlorides and bromides in concentrations below 1 percent were not successful inhibitors.

Conclusion

The tests performed at this laboratory show that further research and study on the use of halides as pickling inhibitors is warranted. Iodides, although having excellent inhibitor properties, are not sufficiently efficient in the concentrations at which commercial inhibitors are commonly employed to be

TABLE V
Inhibition in 5% Nitric Acid

Inhibitor	Concentration %	Rate of Weight Loss mg/cm ² /hr.	Retardation %
Control	30.15	..
NaCl	0.1	31.75	00
NaCl	1.0	4.55	85
NaBr	0.1	32.20	00
NaBr	1.0	2.64	91
NaI	0.01	31.10	00
NaI	0.1	3.54	88
NaI	1.0	2.25	93

considered of possible commercial interest in their own right. However, in combination with various compounds they may prove of some interest as acid pickling inhibitors. Study of the mechanism of passivation is essential because, until recently, the halides were reputed to be accelerators of acid attack.

Acknowledgment

Experimental work was done in Chemistry Laboratory of Ordnance Research and Development Division Suboffice (Rocket), Fort Bliss, Texas.

Publication authorized by the Office of the Chief of Ordnance, Department of the Army, but responsibility for work is personal.

The authors thank Col. H. N. Toftoy and Maj. James P. Hamill for their cooperation and permission to publish this report.

References

1. K. Wickert. *Archiv fuer Metallkunde*, **2**, 56-62 (1948).
2. H. H. Uhlig and R. B. Mears. *Corrosion Handbook*, edited by H. H. Uhlig, pages 21-22 John Wiley & Sons, 1948.
3. Z. A. Iofa and L. A. Medvedeva. *Doklady Akad. Nauk, S.S.S.R.*, **69**, 213-216 (1949); *C. A.* **44**, 1833 (1950).



Discussions

Discussion on "Water Side Deterioration of Diesel Engine Cylinder Liners," by F. N. Speller and F. L. LaQue, *Corrosion*, 6, No. 7, 209-215 (1950) July.

By M. A. Hanson, Gulf, Mobile and Ohio Railroad Shops, Bloomington, Ill.:

The authors are to be complimented on a very fine paper. Our experience has been in agreement with their findings, namely that cavitation attack is limited to the cylinder liners of certain design engines and occurs at the locations and in the manner described in their paper.

A high concentration of alkaline chromates with a pH value of 8.5 or above has been quite effective in reducing cavitation in a number of instances. It also has been noted that appreciable amounts of hardness tends to reduce the effectiveness of the alkaline chromates. The reduction in passivation is believed to be caused by scale formations rendering the passivating films less adherent and more readily ruptured.

In many cases the use of a hardened liner is entirely feasible. Therefore, this paper presents a practical solution to a difficult problem.

A completely satisfactory answer to crevice corrosion in Diesel engines is still to be found. Quite frequently the crevices are in such locations they cannot be packed with sealing compounds. The development of an effective coating would be welcomed.

By Marc Darrin, Mutual Chemical Company of America, Baltimore, Md.:

The paper by F. N. Speller and F. L. LaQue is timely, very interesting and presents information and means of control which are in accord with my thoughts and observations, but there is one thing I would like to mention. It is not a criticism of the paper but of corrosion engineers in general—a fault of which I also have been guilty. It relates to our philosophy or manner of thinking about corrosion.

Years ago when little was known about the mechanism of corrosion it was common to classify different forms of attack as best we could by appearance. As more became known, engineers defined various forms of attack by their primary cause. Obviously this method of classification is better as it suggests ways of control which is a very practical advantage.

To unify our nomenclature, the American Coordinating Committee on Corrosion set up a special committee to define terms. The findings of this committee were accepted and published under the sponsorship of the Electrochemical Society in the 1948 Corrosion Handbook edited by Herbert H. Uhlig of M.I.T. As you know this glossary defines,

in terms of their controlling causation, such forms of attack as corrosion, cathodic corrosion, caustic embrittlement, cavitation erosion, contact corrosion, corrosion fatigue, dezincification, erosion, fretting corrosion, hydrogen embrittlement, season cracking, stress corrosion, etc.

Now I would have no objection if it is said that the appearance of the corroded areas in the Diesel liners is the same as that produced by cavitation erosion, but to call it cavitation erosion implies that this is the controlling factor. The paper just presented shows that this is not the case. Obviously the major factor in the Diesel liners was some form of corrosion since it can be controlled by corrosion inhibitors. It cannot be said to be the same as that in the laboratory vibrated specimens since their attack was definitely mechanical, namely, some form of erosion which cannot be controlled by chemical means. The paper explains this by quoting references that cavitation of the liquid may increase the liquid's chemical activity. If this is so it might be more consistent to call the attack corrosion-cavitation.

In my opinion the mechanism of the attack is of the following type: The liners are weakened by corrosion to a point where the weakened metal is eroded away by comparatively mild vibratory forces leaving a clean honey-combed surface characteristic of cavitation erosion; but this is merely an incidental and final stage—not the controlling factor which is some

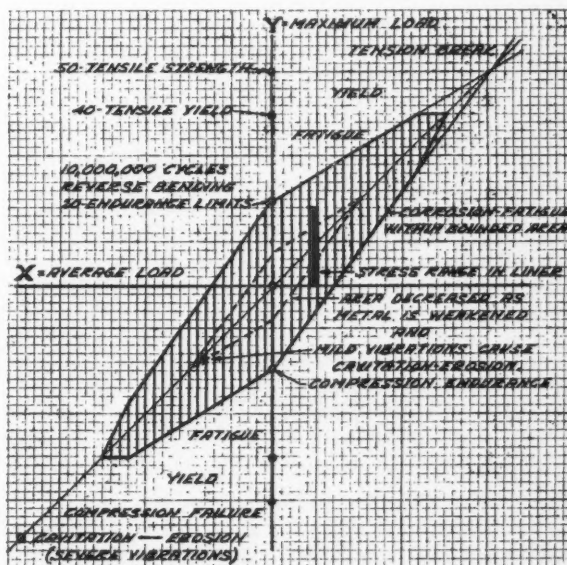


Figure 1—Stress fatigue diagram. Vertical lines within bounded area are permissible stress ranges. Ordinary corrosion at point of origin. Stress-corrosion at other points between endurance limits. Other forms of failure are indicated on chart.

form of corrosion, presumably corrosion-fatigue since the required cyclic stress factors are present in a Diesel liner.

If you will superimpose on a conventional stress-fatigue diagram (see attached illustration) the summation of the maximum cyclic stresses in a locomotive Diesel liner (shown by the heavy black vertical line), it will become apparent that the stage is set for corrosion fatigue, and it seems to me quite remarkable that some liners last even a short time without an inhibitor or the use of corrosion-resistant alloys.

When I first encountered this problem I thought that the trouble was due to design, but after making stress studies and noting how well the maximum stresses center in a comparatively small permissible area, I have come to the conclusion that the design engineers are doing a good job, and that the major problem is now, up to the corrosion engineer and metallurgist. The metallurgist has two approaches: Metals with increased corrosion resistivity, or metals with an increased endurance limit. Both seem to point toward nickel alloys.

In any event it is necessary also to employ a substantial concentration of inhibitor. In cases of corrosion fatigue as encountered in oil well drilling, the required concentration of an inhibitor such as chromate is about five times that needed for protection against ordinary corrosion, which is essentially the same concentration which Speller and LaQue found effective.

By John W. Ryznar, National Aluminate Corp., Chicago, Ill.:

Mr. LaQue and Mr. Speller are to be complimented for bringing their problems to the general attention of workers interested in corrosion problems and indicating the diverse ways in which corrosion can be responsible for the failure of metals in service.

Having been very closely associated with this particular problem since we have supplied corrosion inhibitors to a large number of railroads for protection of Diesel engine cooling systems, I agree wholeheartedly that the problem is caused by factors other than the presence of a corrosive environment. Our experience indicates that in spite of very high inhibitor dosages (in the order of 4000-5000 ppm of chromate expressed as anhydrous sodium chromate) in some Diesel units the attack may be slowed down but not eliminated. While with another particular Diesel cylinder design not one instance has been found of failure due to corrosion or other water side failures over a long period of operation where adequate concentrations of inhibitor were maintained (that is, of the order of 2000 ppm sodium chromate).

In the liners susceptible to the cavitation type of attack we have found this to be true: On a single unit in which the liners all have been subjected to the same water conditions, several liners would be badly attacked while others would show rather insignificant attack. This would indicate that factors other than water or the presence of insufficient in-

hibitor in the water must account for the metal deterioration; also that there are either differences in the magnitude or frequency of vibrations or that there are differences in the metallurgical composition and structure of the liners.

In an examination of two liners with widely different responses we found these differences which may be significant. Both were of the same nickel cast iron of the gray iron type. A liner which was badly pitted at 40,000 miles of service showed the following:

1. Some porosity—probably due to small gas holes.

2. Graphite flakes were quite large and were fairly well distributed. However, in the area of attack this was not true. In this area there was some interdendritic segregation as well as segregated flake sizes. Some small areas were comparatively free from graphite.

On the other liner, which was in good condition at the end of 160,000 miles of service, the metallographic examination indicated that

a) the combined carbon was close to the eutectoid ratio of 0.85 percent. Keeping the combined carbon near the eutectoid ratio tends to increase mechanical strength;

b) little porosity was present;

c) graphite flakes were rather large and in almost all areas showed uniform distribution and random orientation. There was a tendency toward interdendritic segregation and preferred orientation in only one small area near an edge.

There was no evidence of segregated flake size.

I mention this as perhaps being an indication of the improvements that may be possible by more closely controlling certain factors in the production of the castings.

Mr. LaQue recommends a pH be maintained in the range of 8.5 to 9.5. I might mention that, although we supply an inhibitor which has an initial and equilibrium pH in the range of 9 to 9.5, we have had very good results with another which maintains the pH in the range of 7 to 7.5. This inhibitor was developed originally to protect aluminum heads in contact with Admiralty metal tubes in the oil coolers of the Diesel.

It would be interesting to see whether improvements in resistance to attack, using the suggestions offered by the authors, could be demonstrated by the use of high frequency magnetostriction apparatus.

If they could be applied in actual practice and would show improvement in results the mechanism of the attack suggested certainly would be accepted more readily.

I personally favor the cavitation erosion mechanism as best explaining all the conditions encountered.

By John F. Wilkes, Dearborn Chemical Co., Chicago, Ill.:

In addition to apparent cavitation or cavitation-corrosion of Diesel engine cylinder liners, as discussed by Messrs. LaQue and McBrien, cavitation-

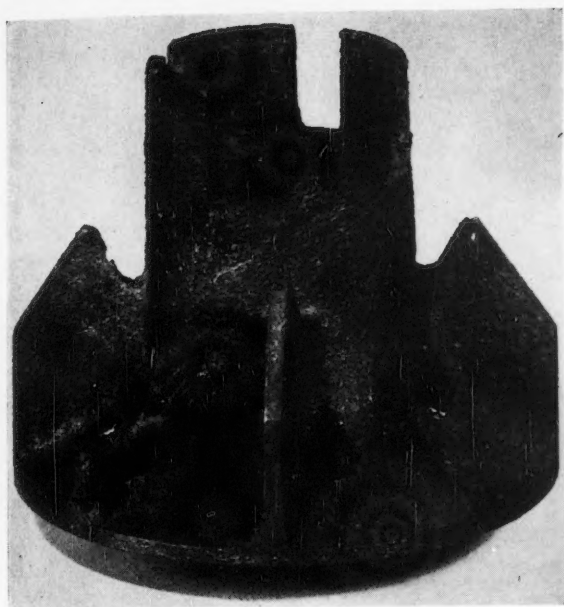


Figure 1—Cavitation-corrosion failure of iron impeller from cooling water circulating pump of Diesel-electric locomotive. Corrosion accelerated by irregular application and inadequate concentrations of chromate corrosion inhibitors.

corrosion may occur at other locations in Diesel circulating systems. For example, cast iron or even bronze pump impellers may fail rapidly, especially if chromate concentrations are inadequate or irregular. See accompanying photograph.

More dangerous attack may occur at inlet ends of tubes in brass radiator sections. Accelerated attack, apparently cavitation, has caused complete penetration of tubes within the first inch or so from the inlet end. No solid corrosion products can be found; pitted areas are bright and new looking. The result of this penetration is water leakage under pressure into the lubricating system, causing destruction of bearings and failure of crankshafts. In several reported cases, this attack occurred when using high pH cooling water (10.5 and above), although chromate content generally was adequate.

Chromate corrosion inhibitors not only must be applied regularly, but protective concentrations must be maintained constantly. Many railroads do not have test departments or readily accessible laboratory facilities to make accurate chromate titrations and must depend on field test methods. Previous test methods have been ineffective. Colorimetric comparisons are hampered by contamination of cooling water with oil or exhaust gas carbon; high chromate concentrations cannot be accurately differentiated visually. Chromate determinations based on conductivity type measurements are subject to errors resulting from dissolved minerals other than chromates. Equipment for both procedures is expensive, fragile.

To replace these field methods, a simple, speedy chromate spot test has been developed. The test uses a prepared blotter-type card incorporating all necessary reagents. In use, one drop of cooling water from the system is placed on the card. After two minutes,

the color developing is compared with a color standard chart to determine chromate strength and dosage adjustments required. Undertreated samples produce blue spots; spots from samples of proper strength are bright gold with narrow blue rims.

By H. H. Uhlig, Massachusetts Institute of Technology, Cambridge, Mass.:

Mr. LaQue made mention of the fact that cathodic protection diminishes damage of a metal by cavitation. He also quoted work done elsewhere to the effect that damage from this source in sulfuric acid is less than one might expect in a corrosive environment. These two facts can be explained consistently by the action of hydrogen bubbles on the metal surface. In the first case bubbles result from discharge on the cathode of hydrogen ions, and in the second case by reaction of the acid with steel. Bubble formation of this kind or any other kind is well suited to cushion the impact of collapsing vacuum cavities formed during the cavitation cycle. Hence, cathodic protection, other than affecting the corrosion rate, may act purely as a physical means for introducing gas at the place where damage is focused. This is in accord with the practice of introducing air into solutions for minimizing damage by cavitation. It also explains why a medium which is more corrosive than water, like sulfuric acid, may sometimes reduce cavitation damage.

This explanation must not be interpreted as an argument opposing the point of view that corrosion also enters the damage resulting from cavitation. On the contrary, information from many sources makes it appear quite likely that chemical reactions at the metal surface often accompany and abet the more obvious mechanical damage.

Authors' Reply:

We wish to thank all those who discussed and criticized our findings.

We are, of course, pleased that our observations are in accord with the experience of others as cited, for example, by Messrs. Hanson and Ryznar.

We are not prepared to fence with our good friend, Marc Darrin, as to the nice distinction he makes between what we call cavitation erosion and what he calls corrosion cavitation. It is well known that the mechanism of cavitation erosion frequently involves the corrosion fatigue he mentions. Corrosion fatigue cracks associated with cavitation erosion frequently intersect so as to permit the ready dislodgment of particles of metal. The principal difference between us is that Mr. Darrin feels that the stresses causing fatigue are associated with the explosive forces within the cylinder, while we believe that they are developed by the collapse of the cavitation voids induced by high frequency vibrations. Where cavitation develops slowly, corrosion is an important factor but where it develops in a few hours it is evidently mainly mechanical in cause. Therefore it is logical when the damage occurs after a reasonable time, to try excess inhibitors first as indicated by

Mr. Hanson. If this does not bring about sufficient relief, metallurgical or damping expedients should be applied.

Where this type of corrosion develops in an engine that otherwise is satisfactory, it can be remedied by proper use of inhibitors and/or minor adjustments to ease the vibration that produces the dynamic damage.

We are glad to have Mr. Wilkes' account of similar experiences with other parts of cooling water systems and the notes on the convenient method of control of inhibitor concentration which his firm has developed.

Dr. Uhlig's suggestion that the cushioning effect of hydrogen bubbles may account for the reduction of cavitation erosion by the application of cathodic protection is an ingenious one. Presumably it could be checked by potential measurements of surfaces subjected simultaneously to cavitation erosion and cathodic protection. We are glad to have his support of our view that in many instances corrosion is a prime factor in cavitation erosion and that, therefore, whatever can be done to arrest corrosion can be expected to be helpful—except where the mechanical factors are greatly predominant as they are in the vibrating type of laboratory cavitation test.

By A. J. Liebman, Dravo Corp., Pittsburgh, Pa.:

The paper covers many phases of the stress corrosion phenomena in a very broad form. Both the laboratory and field tests show that there is a practical limit to the use of water treatments for the total prevention of corrosion damage to Diesel cylinder liners. Therefore stress cavitation damage requires in addition to the water treatments, such mechanical stabilization in the design of engines and liners, which will bring about end frequencies and amplitudes which will fall either below or above those which have been found detrimental to the metals involved.

Stress corrosion follows peculiar patterns in practical applications. Engines have shown severe attacks on some liners and other liners in the same engine were barely discolored. Yet all liners performed under the same firing pressure and the same rpm. The metal was of the same composition, the liners were machined according to the same finish and tolerance. The only basic difference was found in the clearance at the bottom fit of the liner. Those liners with a closer fit on the power slap side would produce greater and earlier failures than those liners with the wider fit or greater tolerance.

When the liners are removed often, a complete pattern can be charted.

1. A discoloration always precedes the crystalline separation.
2. Corrosion products never deposit or form on the area under attack.
3. A crystalline separation of the metal continues on a full pattern of the approximate angularity and form fit of the piston to the liner. The damage always starts on the power slap side of the piston and it always produces much more severe end damages on the power slap side.

4. The damage to the cylinder block appears to be caused by vibrating metal particles of the resulting cavitation corrosion, which deposit at the block-liner interface. This block damage has been observed on the power slap side of the piston only.

It must also be noted that the use of alloy liners did not correct the problem entirely.

Painting of the liners and block interiors was of no value on standard equipment.

Tests of nearly two years indicated that improvements and corrections can be made in the following manner:

1. Stress relieving of liner castings before a) rough, and b) before final machining of the liners.
2. A smooth machined finish of liner O.D.
3. Increased engine rpm and lower firing pressure.
4. Uniform clearance at the top and the bottom block to liner fit.
5. The use of a latex seal coat which is applied to liner directly above the upper O ring.

The one item that may be of some value is the improvement or enlargement of water circulation area or depth and water flow direction in the affected zones. Discoloration of the liner appears very much like metal that operates under high temperatures, and is not cooled sufficiently with the present methods. However, this phase of the study should be made by Diesel motor manufacturers, or by someone conducting specific research on Diesel equipment.

Authors' Reply:

We are glad to have Mr. Liebman's confirmation of some of our observations and particularly his suggestions for avoiding the difficulties being discussed on the basis of his considerable practical experience. It is to be hoped that Diesel research engineers will follow Mr. Liebman's suggestion, as well as ours, so that the importance of vibration in the basic problem can be appraised more precisely and any appropriate action in design and construction can be taken accordingly.

Discussion on "The Behavior of the Chromium Nickel Stainless Steels in Sulfuric Acid." By George C. Kiefer and W. G. Renshaw, *Corrosion*, 6, 235-244 (1950) Aug.

Question, by Paul J. Stuber, Monsanto Chemical Company, Monsanto, Illinois:

Was any work done to measure the amount of hydrogen evolved by stainless steels in sulfuric acid? What I have in mind is the possibility of using stainless steels for non-vented shipping containers for sulfuric acid. In this application excessive hydrogen pressures could not be tolerated.

Authors' Reply:

In regard to Mr. Stuber's inquiry, no means were taken to measure any hydrogen evolution. The use of any of the types of stainless steel for shipping containers for uninhibited acid would probably be lim-

ited to 66° Be acid at a temperature not exceeding 100° F.

Question, by H. F. Haase, Marquette University, Milwaukee, Wis.:

These wrought stainless steels often contain ferrite pools thus forming two phase alloys. Were your alloys metallographically examined and what is the effect of sulfuric acid on such two-phase alloys as compared to single phase alloys?

Authors' Reply:

Dr. Haase asks what effect the presence of ferrite might have on the behavior of the stainless steels in sulfuric acid. Types 304 and 310 are generally free of any appreciable amounts of ferrite. Types 316 and 317 may or may not have any ferrite present, depending on the ratio of chromium and molybdenum to carbon and nickel. While no metallographic examination for ferrite was made on any of the samples, we would expect that the Type 317 samples tested would contain some ferrite and the superior behavior of this steel in sulfuric acid indicates that ferrite, within certain limits, has little effect on the corrosion rate.

Question, by Marc Darrin, Mutual Chemical Company of America, Baltimore, Maryland:

Mr. Kiefer has mentioned that tests were run in solutions made with C. P. chemicals presumably in distilled water. This means that chloride ions were absent. In systems of this type chlorides increase the aggressiveness and difficulty of inhibiting. The data by Kiefer and Renshaw show that Cr-Ni stainless steels in sulfuric acid are passivated by addition of chromic acid or bichromate. The same applies to ordinary steel and iron, providing no appreciable amount of chloride is present. I wonder if Kiefer and Renshaw have found any oxidizing inhibitors effective with Cr-Ni steels in sulfuric acid in the presence of chloride ions?

Authors' Reply:

In reply to Mr. Darrin's question, our work with inhibitors did not cover any instances where appreciable chloride ion was present in the sulfuric acid solutions since we did not want to complicate the picture with still another factor. It has been our experience that small chloride ion concentrations, for example, about 1/25 of 1%, can cause pitting of Type 304 in these inhibited solutions. Type 316 would offer good resistance to pitting under these same conditions.

Where larger amounts of chloride ion are present, there will be sufficient hydrochloric acid formed to cause appreciable attack even with Type 316. We do not believe that it is possible to prevent or inhibit hydrochloric acid attack by the addition of any salts such as can be done with sulfuric acid solutions.

Question, by Frank L. LaQue, International Nickel Company, Inc., New York, New York:

What minimum copper content of the solution is required to insure passivity of different grades of stainless steel in a 5% by weight sulfuric acid solution as

used for pickling brass at within the temperature range 150° to 200° F.?

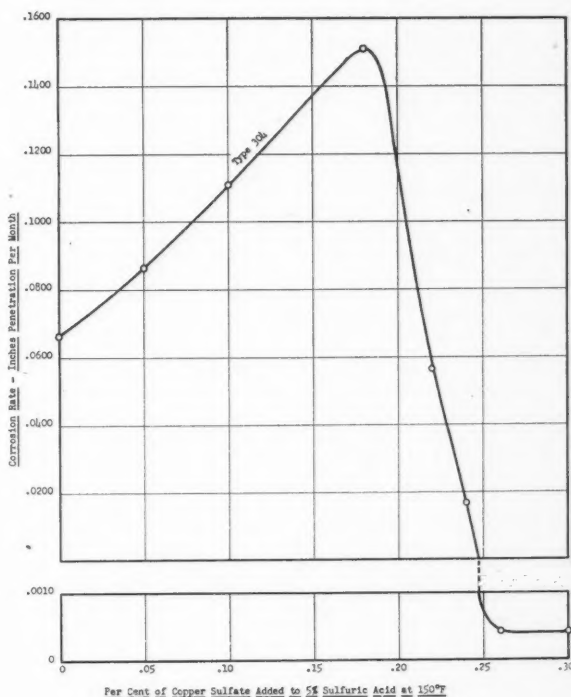
Authors' Reply:

Mr. LaQue's question about a 5% sulfuric acid solution at 150° F. to 200° F. used in pickling brass has very appropriately brought out one of the practical uses of this type of data we have shown. However, only Types 304 and 316 were employed in our work involving copper sulfate additions to 5% by weight sulfuric acid solutions.

Our tests show that the following minimum amounts of copper sulfate would be necessary to inhibit attack by a 5% sulfuric acid solution at 150° F. (65° C.), 175° F. (80° C.), and 200° F. (93° C.) on Type 304 and Type 316 samples we employed.

	105° F.	175° F.	200° F.
Type 304	0.26 %	0.28%	0.30%
Type 316	0.005%	0.01%	0.03%

Lesser amounts than these minimum percentages were found to accelerate the corrosion rate over that shown in the pure acid solution with no additions. This is illustrated by the following curve for Type 304 at 150° F.



Discussion on the "Electrochemical Behavior of Zinc and Steel in Aqueous Media", Part II. By Raymond B. Hoxeng, *Corrosion*, 6, 308-312 (1950) Sept.

Question, by F. N. Alquist, The Dow Chemical Company, Midland, Michigan:

In what form did you add silicon?

Author's Reply:

"Grade N silicate of soda", obtained from Philadelphia Quartz Company.

Question by Frank L. LaQue, The International Nickel Company, Inc., New York, New York:

Were the test solutions aerated?

Author's Reply:

Yes.

Comment, by Frank L. LaQue, The International Nickel Company, Inc., New York, New York:

In considering the electrochemical relationships between zinc and steel in waters, it is suggested that it actually may be more important that the zinc not become cathodic than that it remain strongly anodic. So long as the zinc—or any other impermeable coating, for that matter—does not become cathodic, the effect will be to require whatever corrosion reactions are involved to occur in the rather confined spaces at the bottoms of pores or holidays. Thus, since both the anodes and cathodes must share a limited area of surface upon which they can exist, their extent will obviously be limited. This is especially significant in corrosion reactions under cathodic control where a restricted cathode area will hold corrosion rates within low limits. Furthermore, if the coating is thick enough, there is a good chance that any pores or holidays will become clogged with corrosion products or other insoluble compounds which will also stifle corrosion by interfering with diffusion and by effects on the resistance of the electrolytic cells.

On the other hand, if the zinc coating should become cathodic, that portion of the corrosion reaction

will be permitted to occur over an extended surface freely available to cathode depolarizers. Therefore, even a small shift from an anodic or even neutral galvanic relationship will be accompanied by a gross acceleration of corrosion. As indicated previously, the prevention of such a shift in an unfavorable direction may be more important than the maintenance of an anodic potential and the cathodic protection that goes with it.

Authors' Reply:

We are in complete agreement with Mr. LaQue's comment and hope to obtain long-time service data to prove the point.

Question by D. W. Johnson, Cast Iron Pipe Research Assn., Chicago, Ill.:

Did you do any testing of solutions with CaCO_3 ranging from 350 to 1000 ppm?

Authors' Reply:

No.

Question by H. H. Uhlig, Massachusetts Institute of Technology, Cambridge, Mass.:

Is it your impression that alkaline additions to water in general will shift the potential of zinc in the anodic direction?

Authors' Reply:

No, not necessarily.

ERRATUM

Resistance of Aluminum Alloys to Fresh Waters, by D. W. Sawyer and R. H. Brown.
CORROSION, 3, No. 9, 443-457 (1947) Sept.
See Table I, Page 444. In first column change "Chlorine" to "Chloride."



Topic of the Month

Finding Coating Faults in Buried Pipe Using Pipe Locator and Pearson Method

By L. F. HEVERLY*

THE WRITER has found that the Wahlquist Pipe Locator can readily be used with the Pearson method for locating holidays or faults in pipe line coatings after the line has been back-filled.

Two men with shoe cleats, 20 to 25 feet of insulated single-conductor wire between them, pipe locator receiver with earphones and interconnecting leads covers all the equipment needed by the holiday detecting crew. The pipe locator transmitter is connected to the line in the usual manner for the conductive method of locating a pipe line.

In using this equipment, it is desirable to use the interrupted signal from the transmitter. Just as in its regular use as a pipe locator, the transmitter output terminals marked "Common" and "Low" are used in cases where the pipe-to-ground-rod overall circuit-resistance is less than 150 ohms; "Common" and "High" output terminals are used when this circuit resistance exceeds 150 ohms.

When starting to walk the line, the volume of the pipe locator receiver should be adjusted so that the interrupted signal can just barely be heard. Consistent with the Pearson method, as a holiday is approached by the lead man, the tone gradually becomes louder and reaches a maximum, then diminishes as he passes by the holiday. The same process occurs as the second man with the receiver approaches and passes the holiday. An output indicating meter can be bridged across the earphone circuit to give a visual indication for more accurately spotting the holiday location. However, it has been found that with a little practice, the approximate peak location of the signal (plus or minus a few inches) can be ascertained without the aid of the output meter.

Incidental to the use of the pipe locator as a holiday detector, it has been found that areas of different soil resistivities can be determined. The low interrupted tone as initially adjusted increases in intensity when walking over soil or greater resistivity than that where initial adjustment was made and decreases or fades out entirely when walking over soil of lower resistivity



Figure 1—Holiday detector crew showing J. H. McBrien in front and L. F. Heverly in back.

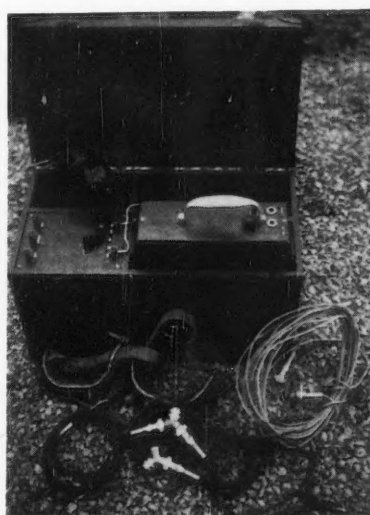


Figure 2—Wahlquist pipe locator (receiver unit slightly raised in box); one pair of shoe cleats, 25-foot coil of insulated single conductor wire, amphenol connectors and interconnecting wires.

than that where initial adjustment was made.

The writer and other Great Lakes corrosion engineers have adopted the Wahlquist Pipe Locator as standard equipment for locating coating holidays or faults using the Pearson method for the following reasons:

1. The frequency range and high power output of the transmitter provide a signal that can easily be traced from four to seven miles in either direction from the transmitter connection point. The actual distance that can be walked depends largely upon the resistance of the pipe-transmitter-ground-rod circuit and the soil terrain being walked whether wet or dry, clay, sandy or rocky.

2. The receiver is very light. We have found it easier and more comfortable to carry the receiver in one hand (see Figure 1) than use a harness to hold it against the rear operator's chest.

3. It is not necessary to use shielded wire between the operators; any stranded single-conductor insulated wire may be used.

4. In the case of an old buried line, where there is some question as to the exact location of the pipe line, the plug in the external coil jack of the receiver (that connects the shoe cleats of each operator to the amplifier receiver circuit) can be removed and the receiver then assumes its normal function as a pipe locator.

5. The pipe locator receiver operates quite satisfactorily in the vicinity of power lines. The amount of noise induced by a power line depends primarily upon how good a ground connection each operator obtains with his shoe cleats. However, even with power hum induction, the interrupted signal normally can be heard because of the selective qualities of the human ear. Coating holidays located in these areas have readily been determined by decreasing the volume of tone to the earphones. As a coating holiday is approached, this decrease in overall tone results in an increase of the signal-to-power-noise ratio.

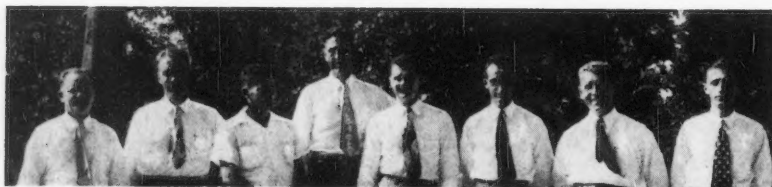
6. It is not necessary to walk directly over the pipe line. It has been found that by walking alongside a newly-backfilled line that holidays can be located just as well as when walking on top of the rough backfill.

* Chief Corrosion Engineer, Great Lakes Pipe Line Company, Kansas City, Mo.



NACE News

Members to Be Canvassed on Abstract Card File



Among instructors at Shreveport NACE Section's Practical Pipe Line Corrosion Control Short Course were the above, left to right: H. V. Beezley, United Gas Pipe Line Co.; W. A. Broome, Arkansas-Louisiana Gas Co.; Pete Smith, Interstate Oil Pipe Line Co.; C. W. Evans, United Gas Pipe Line Co.; M. J. Olive, John Wise, both of Arkansas-Louisiana Gas Co.; Paul Busch, Texas Eastern Transmission Corp., and Bill Levert, United Gas Pipe Line Co. Scene at right shows several of the 94 registrants inspecting the air-cooled rectifier installation during the second day field tour. Some engineers attending were from points as distant as New York, Birmingham and Corpus Christi.

Houston Section Holds First Fall Meeting

First fall meeting of Houston Section was attended by 85 members and guests September 11. The program consisted of three short addresses on underground corrosion and a talk by Jess Neely, Rice Institute athletic director and football coach, who discussed Southwest Conference football and the new Rice Institute stadium now under construction.

The technical program, moderated by L. G. Sharpe of Humble Pipe Line Co., consisted of the following talks, which were followed by discussion from the floor. Pipeline Coatings by R. A. Brannon, Humble Pipe Line Co.; Cathodic Protection of Pipe Lines by Wayne Broyles, Brance-Kracy Co., and Protection of Tank Farms by D. H. Bond, Texas Pipeline Co.

L. G. VANDE BOGART

Funeral services were held at 11 a.m. September 13, 1950, for L. G. Vande Bogart, Research Engineer for the Crane Company, Chicago, a 1946-47 director of NACE, and active in association affairs up to the time of the illness preceding his death. Born at Sheboygan Falls, Wis., he joined Crane Company in 1923. He was first chairman of the Corrosion Division of the Electrochemical Society and was active in other professional organizations. For eighteen years of his work with the Crane Company his chief concern was the corrosion of valves and piping.



NACE CALENDAR

October

- 17—Chicago Section. Program: Panel, "Corrosion of Electric and Gas Systems."
- 17—Cleveland Section.
- 18—Los Angeles Section.
- 19—Northeast Region. Trustees, general business.
- 25—Corpus Christi Section.
- 27—Joint meeting Philadelphia Section, ASM, Engineers Club, Philadelphia. (Tentative)

November

- 1—New York Section.
- 15—Joint Northeast Region—Western New York Section meeting.
- 21—Cleveland Section. Symposium on Materials of Construction, Hotel Carter, Cleveland.
- 21—Chicago Section. Speaker, Vance N. Jenkins, NACE President.

Pittsburg Officers

Pittsburgh Section 1950-51 officers have been named as follows: V. V. Kendall, National Tube Co., chairman; J. M. Bialosky, Carnegie-Illinois Steel Corp., vice-chairman; F. E. Costanzo, Manufacturers' Light & Heat Co., secretary, and W. W. Binger, Aluminum Research Laboratory, treasurer.

Members of the NACE will be canvassed by Central Office in the near future to determine the extent to which they will be interested in the proposed Corrosion Abstract Master Punch Card File in Central Office. This card file, to consist of abstracts of corrosion literature collected by the NACE Abstract Committee, will be made up of McBee system punch cards, indexed and cross-indexed for rapid sorting by that system.

The file is expected ultimately to have copies of all abstracts on corrosion to which the association has access. Initially, however, an effort will be made to set up cards on abstracts which are being handled currently for publication in the Corrosion Abstract Section of CORROSION magazine. Simultaneously, an effort will be made, as time permits, to begin preparing punched cards on abstracts which already have been published in CORROSION magazine in former years, and those which have been collected otherwise.

Purpose of setting up the file is to provide association members and others a reference source including all known published material on corrosion. Extensive privately operated systems are in existence which include reference to certain fields of corrosion, but no known reference system devoted exclusively to corrosion matters covers all aspects of the problem.

Purpose of the canvass of the membership is to get some indication of the extent to which members may be expected to use the services the master index file will make possible. Intensive investigation into the cost aspects of the problems has resulted in the accumulation of reasonably reliable figures which may be used initially to establish basic charges. Services proposed initially by NACE from the system include:

1. Supplying on an annual basis printed copies on punch cards of all abstracts added to the master file during the year. It is believed those interested in receiving this service will be required to contract for it annually in advance.

2. A search service in which investigators may select topics of special interest and get bibliographies or abstracts of published technical materials in the selected topics on either a time or cost-per-title basis.

Publication of annual or biennial volumes of corrosion abstracts will be continued. In preparation now is the volume to include abstracts of articles published in 1946-47.

Changes in officers, or changes in addresses of officers should be brought to the attention of Central Office by secretaries of NACE regions and sections. Changes will be made as soon as possible in the monthly list "Directory of Regional and Sectional Officers."

Some Significant Decisions at August 5 NACE Executive Committee Meeting Given

A summary of some of the significant decisions reached at a meeting of the NACE Executive Committee held August 5, 1950, at the Statler Hotel, St. Louis, Mo. extracted from minutes of the meeting compiled by A. B. Campbell is given below. Present for the meeting were V. N. Jenkins, N. E. Berry, R. B. Mears, R. A. Brannon, A. B. Campbell, all members of the committee and L. B. Donovan and Ivy M. Parker.

Expenses of Technical Practices Committees, will be considered each case on its merits and upon approval of a proposal for reimbursement by the chairman of the committee and the executive committee, will be paid. Committees were advised to use the facilities of Central Office to the fullest extent.

A comparison of the preliminary research to be conducted by the Steel Structures Painting Council with the work projected by the NACE Technical Practices Committee will be made before a decision is reached on a request to contribute to the steel structures council.

Trade associations are ineligible for corporate memberships in NACE.

Cuts used in CORROSION will be offered to the authors of articles in which they appear for a handling and mailing charge of \$5, six months after publication of articles. Cuts unclaimed by authors will be destroyed after that interval.

Region and Section officers should be members of NACE. Exceptions will be made when new sections are being organized.

Memberships in sections or regions and not in the national organization of NACE are not authorized. Guests may attend meetings but may not become members unless they apply for membership in the usual way.

A representative of NACE on the Standard Definitions and Terminology

Sub-Committee of the Inter-Society Corrosion Committee will be named.

NACE members will be canvassed to determine to what extent they may use the services to be provided by establishment of the proposed Master Index Card Corrosion Abstract file at Central Office.

Copyrighting or registering the NACE emblem and/or the title "Corrosion" of CORROSION magazine will be investigated by the executive secretary.

All three amendments to the Articles of Organization and By-Laws of NACE voted on by membership were approved, including alternate "B" to Amendment 3, it was certified by the committee.

Pre-Registration Plans Are Made for New York

F. E. Kuhlman, chairman of the Registration and Information Committee for the 1951 NACE

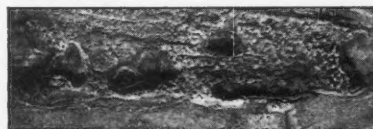


Conference and Exhibition, is planning an efficient method of advance registration which is expected to simplify past registration practices. This follows the trend in other organizations which find advance registration to be beneficial both to organizations and members in eliminating much of the confusion arising in early days of a meeting. Pre-registration information will be mailed sufficiently in advance of the conference so all members may become familiar with the program in time to handle registration details before arriving at the Statler Hotel.

10-YEAR TRIAL RUN ...Tests DAMPNEY Vinyl Coating



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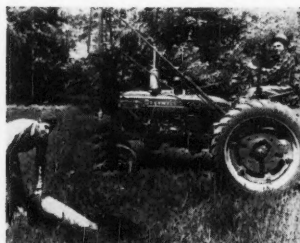
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E-13



NACE 1951 Conference and Exhibition Local Arrangements Committee. Standing, left to right, W. Aretz, hospitality; G. Hull, Jr., printing; T. May, Conference coordination; M. Bermann, transportation; R. Young, entertainment; F. LeFebvre, hotel and meeting rooms; F. Kuhlman, registration information. Seated, left to right, E. R. English, publicity and secretary, Local Arrangements; H. L. Hamilton, chairman Local Arrangements and Assistant General Chairman; L. B. Donovan, General Chairman.

Reports made to H. L. Hamilton, chairman of the Local Arrangements Committee for the 1951 NACE "March in New York" Conference and Exhibition indicate the various committees are organized already and are putting into effect coordinated plans for a successful conference. The Local Arrangements Committee above was photographed at a meeting held September 7 at the Statler Hotel, New York City under leadership of Mr. Hamilton. L. B. Donovan, general chairman of the conference committee stated reports of all committees are indicative of a very successful conference.

Tabular Cross-Index of Technical Material In Corrosion 1945-49 to Be Published

Tabular forms for the compilation of the 5-Year Index to technical material published in *CORROSION* in the years 1945-49, inclusive have been sent to members of the NACE Abstract Committee for indexing. The abstract committee agreed to index the first five volumes of *CORROSION* while the indexing of Volume 6 for 1950 will be done by the NACE editorial review committee.

The index will be that recently completed for use in preparation of the Master Index Card File of Corrosion Abstracts, setting up of which is contingent on further decisions by the association's board of directors. Considerable study of the advisability of using this index for the purpose of providing cross references for all the technical material printed in *CORROSION* magazine during 1945-49 resulted in a decision to use it not only for the 5-year index, but also for the annual indexes. The principal advantages are that it makes all indexing of technical materials by the association uniform, and provides a ready means of cross-indexing without the use of excessive space.

Plans have been made to publish the 5-Year Index in the December issue of *CORROSION*. This issue also will include the annual index to technical material published in 1950. The 5-year index will incorporate the following sections:

The NACE Abstract Index
Tabular cross-index of 1945-49 technical articles.

Author, alphabetical index.

It is planned also that the 5-year index will be published separately for those who wish to have it.

Electrochemical Society

Papers on corrosion will be presented in three sessions during the Electrochemical Society, Inc. meeting at Hotel Statler, Buffalo, New York, October 11-13. Sessions will be held October 11, morning and afternoon and October 12, morning.

"Special Issues" of Corrosion Scheduled

So-called "special" issues of *CORROSION* magazine during 1951 have been established as follows, following decisions by the association's executive committee and as a result of other activities of the association:

Annual Directory Issue—To be published in March, 1951.

Annual Conference Issue—To be published in February, 1951.

Annual Index Issue—To be published in December, 1951.

The annual directory issue formerly was published in January, and the annual conference issue is published in the month preceding the annual conference, scheduled for March 13-16, 1951, in New York. The annual indexes always are published in December.

Association policy for these issues has not been changed otherwise. Circulation and advertising rates are the same as for other issues during the year.

Paper on Pipe Line Corrosion by Wade Set for Region Meet

"Corrosion Problems to be Considered in the Design of New Pipe Lines to be Constructed in Eastern Metropolitan Areas," by O. W. Wade, Transcontinental Pipe Line Co., Houston, Texas, will be presented from 11 to 11:20 a.m., Monday, October 9, during the South Central Regional meeting to be held at Rice Hotel, Houston. The title of this paper was omitted in error from the news story published in *Corrosion* in September.

The two-day session, October 9 and 10, will be preceded Sunday by several technical committee meetings to which visitors are invited.

Annual Directory of NACE to Be Printed In March Issue

A change in the time of publication of the Annual Directory of the membership of the National Association of Corrosion Engineers from the January issue of *CORROSION* to the March issue has been approved by the association's executive committee. A. B. Campbell, executive secretary of the association has advised.

The decision to change the month of publication of the directory followed a study of directories issued by the association in the last three or four years. Because of publication deadlines, the directories published in January have not included many changes in address and other data related to members which become known only after receipt of returns from mailing of membership statements. This mailing usually is consummated in December, and the returns come in too late to be incorporated in a directory published in January. The result has been that a large number of corrections of addresses and affiliations must be published in the February and March issues.

Change in the publication time to March, Mr. Campbell asserted, will make possible in the first place a more accurate annual directory, and in the second place will eliminate the publication of the large number of changes which have been made in previous years immediately after issuance of the annual directory.

No other changes in policy respecting the directory or the issue of *CORROSION* in which it will be published were announced by Mr. Campbell.

Personnel of TP-6G Committee is Listed

Members of TP-6G—Surface Preparation for Organic Coatings responsible for preparation of First Interim Report—Recommend Practices for Surface Preparation of Steel (NACE Publication 50-5, *Corrosion*, 6, No. 8, 276-282 (1950) Aug.) are as follows:

A. J. Liebman, Dravo Corp., Pittsburgh, Pa., chairman; Frank Smith, E. I. DuPont de Nemours & Co., Inc., Chicago, Ill., vice-chairman. Members: J. A. Boylan, Parker Rust Proof Co., Detroit, Mich.; George Burditt, American Wheelabrator & Equipment Co., Pittsburgh, Pa.; George C. Cox, consulting engineer, Charleston, W. Va.; J. A. Davenport, U. S. Corps of Engineers, Cincinnati, Ohio; George Diehlman, National Lead Co., Brooklyn, N. Y.; R. S. Freeman, Cities Service Refining Co., Lake Charles, La.; S. C. Frye, Bethlehem Steel Co., Bethlehem, Pa.; J. C. Hudson, British Iron and Steel Association, Birmingham, England; Max Kronstein, University of New York; Frank L. LaQue, International Nickel Co., Inc., New York; R. Rhea, U. S. Corps of Engineers, Louisville, Ky.; L. R. Whiting, Bakelite Corp., New York.

Hackerman Named Electrochemical Editor

Norman Hackerman, associate professor of chemistry and director of the corrosion research laboratory at the University of Texas, Austin, has been named technical editor of The Journal of the Electrochemical Society, according to an announcement in the May issue of the periodical. He succeeds Harold J. Read, resigned.

Marine Boiler Article Reprints May Be Made

Reprints of the article "Marine Boiler Deterioration," by I. G. Slater and N. L. Parr of the Royal Navy Scientific Service, England, can be made if a sufficient number of copies are ordered. The article, published in the December, 1949 issue of CORROSION, aroused a great deal of interest among persons and firms interested in boiler corrosion and a number of inquiries for copies could not be filled in full because of the limited number of copies of CORROSION available.

The new reproduction process for reprints now in use by Central NACE office makes it possible now to reproduce the article by lithography. If as many as 200 copies are ordered the cost per copy will not be in excess of 50 cents. No order for less than 25 copies will be accepted, and all orders will be accepted contingent on a sufficient quantity being ordered to make it practical

to reprint. The reprints will consist of separate sheets printed on both sides, stapled once in the left hand corner. No special imprints, or other alterations will be made.

Orders for these reprints should be addressed to Central Office NACE before December 15, 1950. If a decision is reached not to reprint, those sending orders will be notified by mail.

Printing Plates Are Offered to Authors

Authors of technical articles published in CORROSION will be given the opportunity to secure cuts used in the printing of their material six months after publication. Cuts of individuals are not included. The decision to offer the cuts to authors, at a flat handling charge of \$5, was made by the NACE Executive Committee at its August 5 meeting in St. Louis, it was announced by A. B. Campbell, executive secretary of the association.

Cuts not claimed during the six months' period after publication will be destroyed.

Authors of papers published in CORROSION during the years 1945-49, inclusive, who wish to secure their cuts may request them by writing to Central Office, giving a complete reference of the article in which the cuts were used. There is no certainty NACE will be able in every instance to supply all cuts, as some may have been loaned, lost or damaged. Whenever they are available, however,

and especially for articles published in 1949 (cuts for which are filed at Central Office), they will be collected and shipped on receipt of the request plus the \$5 service charge.

NOTICE TO AUTHORS OF TECHNICAL ARTICLES PUBLISHED IN CORROSION

Central Office NACE will attempt to ship on request of authors of technical articles published in CORROSION during the years 1945-49, inclusive, printing plates used in publishing their articles in CORROSION: 1) To the extent that cuts still are available in NACE cut files, and 2) After payment of a \$5 service charge.

NACE accepts no responsibility for cuts missing for any reason. NACE will retain for its own use cuts of individuals.

This offer will expire as of December 1, 1950, after which date all cuts unclaimed in the years 1945-49 will be destroyed.

Cuts used in the publication of technical articles in 1950 will be made available on the same basis six months after publication in CORROSION.



The Gal would no doubt be welcome on a desert isle, back row of a movie, Saturday night square dance or any other civil (or un-civil) occasion. All Right, All Right, the Gal's name is Maude and her phone number is Webster 941. Now, will you read the rest of this?

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Corrosion Interest Papers Are Scheduled at Metal Congress

Petroleum Mechanical Meeting Includes Corrosion Material

The Fifth Annual Meeting of the Petroleum Mechanical Conference with a theme of cost reduction was scheduled to be held September 24-27 at New Orleans. The conference is a function of the American Society of Mechanical Engineers.

Technical papers of corrosion interest included: Refinery Materials. Corrosion in Amine Plants by C. L. Blohm, and F. C. Riesenfeld, respectively assistant manager and research chemist, The Fluor Corp., Ltd., Los Angeles, Cal. A Standard Laboratory Corrosion Test for Material in Phosphoric Acid Service, by M. A. Scheil and H. F. Ebling, A. O. Smith Corp., Milwaukee, Wis. Corrosion of Alloys at High Temperature with Especial Reference to Attack by V_2O_5 by R. A. Kozlik and E. M. Skinner, The International Nickel Co., New York City.

Production Materials. Study of 9 percent Nickel Tubing in Corrosive Condensate Wells by L. W. Vollmer and C. N. Bowers, respectively director and section head, M. and P. Chemical Division, Gulf Research and Development Co., Pittsburgh, Pa. Protection of Structures Exposed to Sea Water by B. B. Morton, corrosion engineer, The International Nickel Co., New York.

Offshore Operations. Operation of Submarine Pipe Line and Production Facilities in the Gulf of Mexico by G. W. Osborne, The California Co., New Orleans, La.

MEETINGS

1950
Oct.

4-6—American Hot Dip Galvanizers Association, Inc., Greenbriar Hotel, White Sulphur Springs, W. Virginia.

11-13—The Electrochemical Society. Hotel Statler, Buffalo, N. Y.

23-27—American Society for Metals, American Welding Society, Metals Branch, American Institute of Mining and Metallurgical Engineers, Society for Non-Destructive Testing, Chicago, Ill.

Nov.

2-3—Eighth Annual Pittsburgh Conference on X-ray and Electron Diffraction, Mellon Institute for Industrial Research, Pittsburgh, Pa.

Dec.

3-6—American Institute of Chemical Engineers, Neal House, Columbus, Ohio.

1951
Jan.

15-18—Second Plant Maintenance Show, Cleveland, Ohio.

March

5-9—American Society for Testing Materials, Netherland Plaza Hotel, Cincinnati, Ohio.

19-23—Seventh Western Metal Show, American Society for Metals, Oakland, Cal.

**Corrosion
News Deadline:
10th of Month
PRECEDING
Date of Issue**

Scheduled technical papers of possible corrosion interest during the 32nd National Metal Congress and Exposition, Chicago, Ill., October 23-27 include:

Oct. 22—Diffusion and High Temperature Oxidation by C. Wagner, Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 23—Formation of Oxides on Some Stainless Steels at High Temperatures by H. M. McCulloch, Sylvania Electric Products Co., Long Island, N. Y., M. G. Fontana, Ohio State University and F. H. Beck, Ohio State University, Columbus, Ohio.

Oxidation of Pure Iron by J. K. Stanley and Miss J. von Hoene, Research Laboratories, East Pittsburgh and R. T. Huntoon, Carnegie Institute of Technology, Pittsburgh.

Oct. 24—Nickel-Aluminum-Molybdenum Alloys for Service at Elevated Temperatures by H. V. Kinsey, Metallurgical Engineer, Department of Mines and Technical Surveys, Ottawa, Can., and M. T. Stewart, National Research Council of Canada, Ottawa, Canada.

Formation of Austenite in High Chromium Stainless Steels by C. B. Post and W. S. Eberly, The Carpenter Steel Co., Reading, Pa.

Influence of Austenizing Time and Temperature on Austenite Grain Size of Steel by O. O. Miller, U. S. Steel Corp., Kearny, N. J.

Carbide Precipitation in AISI Type 304 Stainless Steel. An Electron Microscope Study by E. M. Mahla and N. A. Neilsen, E. I. DuPont de Nemours & Co., Wilmington, Del.

Some Aspects of Graphitization in Steel by G. V. Smith, J. A. MacMillan and E. J. Dulis, U. S. Steel Corp., Kearny, N. J.

Embrittlement of Stainless Steels by Steam in Heat Treating Atmospheres by C. A. Zapffe and R. L. Phebus, Baltimore, Md.

Preparation and Properties of Titanium-Chromium Binary Alloys by D. J. McPherson, Armour Research Foundation, Chicago, and M. G. Fontana, Ohio State University, Columbus, Ohio.

1950 Educational Lectures

Oct. 23—Oxidation by Carl Wagner, MIT, Cambridge, Mass.

Oct. 24—Corrosion Tests vs Service Performance by Frank LaQue, International Nickel Co., New York.

NACE MEMBERS

IF You Change Addresses

IF You Change Company Affiliation

IF You Change Positions

Please notify the Central Office NACE, 919 Milam Building, Houston 2, Texas, so that you will get CORROSION without delay and that association records can be kept abreast of your progress.

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FAHRITE

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PD Abstracts Yearly Subscriptions Offered

Prevention of Deterioration Abstracts, published by the National Research Council (Prevention of Deterioration Center, Room 204) 2101 Constitution Ave., Washington 25, D. C., are offered for subscription on a yearly basis at \$50, which includes two binders, index tabs, approximately 2000 loose-leaf pages and subject and author indexes annually. Volume year is July-June. Headings covered are biological agents, electrical and electronic equipment, fungicides and other toxic compounds, lacquers, paints and varnishes, leather, lubricants, metals, miscellaneous, optical instruments and photographic equipment, packaging and storage, plastics, resins, rubbers and waxes, textiles and cordage, wood and paper.

Steel Castings Design Awards to Be Given

Fifteen awards totaling \$1000 for papers dealing with development of new applications and uses for steel castings are being offered by the Steel Founders' Society of America, 920 Midland Bldg., Cleveland 15, Ohio. Closing date for the competition is December 1, 1950. Additional information may be obtained from F. K. Donaldson, executive vice-president of the society at the address given.

Pittsburgh X-Ray and Electron Diffraction Conference Programs Corrosion Papers

Among the papers of corrosion interest scheduled to be presented at the Eighth Annual Pittsburgh Conference on X-ray and Electron Diffraction at Mellon Institute, Pittsburgh, Pa. November 2 and 3 are:

November 2—Symposium on Small Angle Scattering. Observations on Long Spacings in Synthetic Organic Polymers, E. P. H. Meibohm and A. F. Smith, Chemical Department Experimental Station, E. I. duPont de Nemours and Co., Wilmington, Del.

Symposium on Silicate Chemistry. Intermediate Stages in Dehydration of Silicates and Related Compounds, Howard F. McMurdie and B. M. Sullivan, Constitution and Microstructure Section, U. S. Department of Commerce, National Bureau of Standards, Washington, D. C. The Decomposition of FeO in Oxide Films and Scales on Iron, Earl A. Gulbransen and Roswell Ruka, Westinghouse Research Laboratories, East Pittsburgh, Pa. X-ray Diffraction Study of Solid State Reaction in the Ternary System MgO-ZrO₂-SiO₂, Wilfried R. Foster, Champion Spark Plug Co., Ceramic Division, Detroit, Mich.

November 3—Symposium on Metals. Temperature Diffuse Scattering from Single Crystal β Brass, H. Cole and B. E. Warren, Massachusetts Institute

of Technology, Cambridge, Mass. Precipitation and Diffuse Scattering in an Fe-Mo-Co Alloy, A. H. Geisler and F. E. Steigert, Research Laboratory, General Electric Co., The Knolls, Schenectady, N. Y. Stress Measurement by X-Ray Diffraction, John Norton, Massachusetts Institute of Technology, Cambridge, Mass. An Electron Diffraction Study of the Structures on Antimony Electrodeposited on the Cleavage Face on Antimony. Single Crystal, Ling Yang, Frick Laboratory, Princeton University, Princeton, New Jersey. The Use of Electron Diffraction Reflection Techniques in the Study of Solid Phase Reactions and Transformations, Earl A. Gulbransen, Westinghouse Research Laboratories, East Pittsburgh, Pa.

The conference will sponsor an exhibit of diffraction cameras and other accessories and equipment. Those interested in displaying items should notify Dr. Robert L. Collin at Mellon Institute. A fee of \$2 will be payable by all except students and pre-registration is requested. Hotel accommodations should be secured individually.

Two French scientists are scheduled to address the conference: Prof. Andre Guinier of the Conservatoire National des Arts et Metiers, Paris and Mlle. Yvette Cauchois of the Laboratoire de Chemie Physique, University of Paris.

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MIT Fatigue and Fracture Conference Papers to Be Printed

Papers presented June 19-22, 1950, at a special Conference on the Fatigue and Fracture of Metals held as part of the summer session at the Massachusetts Institute of Technology will be published in the technological press in about eight months, John J. Rowlands, director of the MIT news service, says.

The program included the following papers:

General Survey of Fracture and Fatigue, M. Gesamer, Carnegie-Illinois Steel Corp.

The Fatigue Problem in Airplane Structure, H. L. Dryden, National Advisory Committee for Aeronautics.

Brittle Fracture and Fatigue in Ships, Rear Adm. C. D. Wheelock, Department of the Navy.

Brittle Fracture and Fatigue in Machinery, R. E. Peterson, Westinghouse Electric Corp.

Internal Stress and Fatigue, O. J. Horger and H. R. Neifert, Timken Roller Bearing Company.

Designing for Fatigue, R. L. Templin, Aluminum Company of America.

Fundamentals of Brittle Behavior in Metals, E. Orowan, Cambridge University, England.

The Statistical Aspects of Fatigue Failure and Its Consequences, W. Wei-

bull, Royal Institute of Technology, Sweden.

Significance of Cumulative Damage in Fatigue, N. M. Newmark, University of Illinois.

Significance of Transition Temperature in Fatigue, C. W. MacGregor, Massachusetts Institute of Technology.

Influence of Metallographic Structure on Fatigue, P. L. Teed, Vickers-Armstrong, Ltd., England.

Embrittlement and Fracture at High Temperature, N. J. Grant, Massachusetts Institute of Technology.

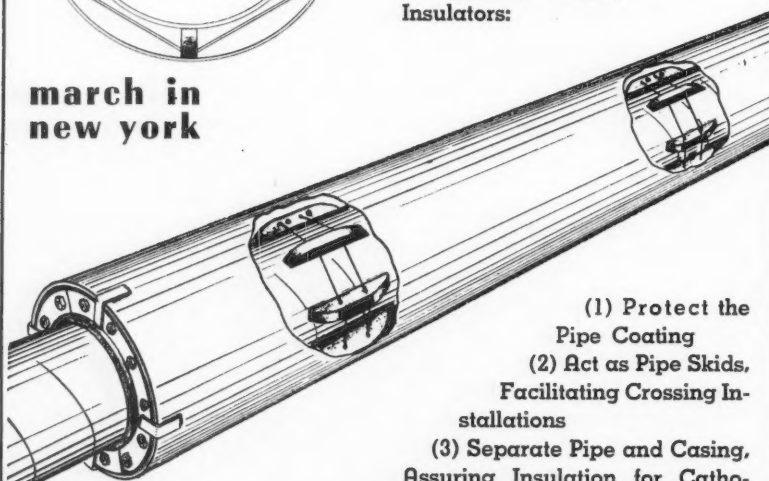
Experimental Techniques in Physical Metallurgy, J. T. Norton, Massachusetts Institute of Technology.

Panel discussions were held on the General Problem, Loading and Testing, Designer's Requirements, Mechanism of Damage and High-Temperature Effects.

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Stress Corrosion Tests On Magnesium Are Given in NBS Report

Results of experiments conducted by H. L. Logan and H. Gessing of the National Bureau of Standards to determine the stress corrosion resistance of wrought magnesium alloys are reported in Technical Report 1464. Research was done at request of the Bureau of Aeronautics, Department of the Navy. Tests were conducted in both a marine and inland atmosphere on sheet materials MI, AZ31X, AZ51X, AZ61X and a clad alloy in which a core of AZ31X sheet was sandwiched between thin layers of MI alloy. Extrusions studied were the ZK-60, AZ61X, AZ80X and AZ80X-HTA.

In general susceptibility of magnesium alloys to stress corrosion in weather increased with aluminum content up to about 6.5 percent aluminum. Specimens stressed at Washington, D. C., site failed sooner than those exposed to the same stresses in a marine atmosphere. On the other hand damage to unstressed specimens at the Washington site was small measured by losses in tensile properties. Of those tested the MI-clad AZ31X alloy was most resistant to stress corrosion. Specimens of this alloy were exposed in a marine atmosphere stressed to 30,000 lb. sq. in. (90 percent of yield strength) for 500 days without failure. Among the bare alloys, the MI-h sheet and the ZK-60 extruded material were outstanding in stress corrosion resistance. Of the remaining alloys bare AZ31X-h material proved most resistant to stress corrosion. The extruded AZ80X material was more resistant to stress corrosion in the heat-treated and aged condition than in the "as extruded" condition. (For further details see "Stress Corrosion of Wrought Aluminum Alloys," by Hugh L. Logan and Harold Hession, J. Res. NBS, 44, 233 (1950).)

The Twenty-third Session of the Congress of Industrial Chemistry is scheduled to be held at Milan, Italy, September 17 through 23. The congress is sponsored by the Society of Industrial Chemistry, 28 Rue St. Dominique, Paris (7) France. At the same time there was held the Seventh National Congress of Italian Chemistry. Twenty-two technical sections were held on topics ranging from farming to radioactive substances.

Clippings on Corrosion

Extracted from Current Periodicals

PROPORTIONS, MIXING GOVERN CORROSION OF CONCRETE

(From Jackson, Tenn., *Sun*, May 7, 1950)

Farm specialists at the University of Tennessee are reported to be of the opinion "Only sound, well-graded aggregate and clean water should be used in mixing concrete. County agents can recommend ratios for various uses where resistance to wear, corrosion and weather are the controlling factors."

ARCHITECTURAL USE OF STAINLESS STEELS GROWING

(From *New York Times*, June 18, 1950)

One steel executive thinks architecture eventually will consume as much stainless steel production as now is devoted to all uses.

Allegheny Ludlum Steel Corporation will erect a new research laboratory with stainless steel curtain walls instead of conventional masonry walls. General Electric Company has constructed the world's first office building of stainless steel . . . offices of a new turbine plant at Schenectady, N. Y.

The thinner steel curtain walls are claimed to provide more usable inside space and to be faster erected.

Carbon steel plates to be used for facing of two 26-story apartment buildings in Chicago will be painted for protection.

METAL CASES SEAL BI-METAL DISK, STRIP THERMOSTATS

(From *Products Engineering*, Albany, N. Y., August, 1950)

Corrosion-resistant metal cases are hermetically sealed around new bi-metal disk and strip thermostats. Terminals are soldered into steel tubes having same expansion coefficient as the hard glass insulator bead surrounding them.

ARMY SEEKS TO CUT USE OF STAINLESS METALS

(From *Business Week*, New York City, August 19, 1950)

The army is trying an anti-corrosion coating nitriding to cut down on the use of stainless metals.

The Interior Department is investigating the properties and potentialities of alternate materials (titanium for stainless, or zirconium for tantalum).

MEMBERSHIP CARDS AVAILABLE

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.

McCabe Heads New Air Pollution Group

Louis C. McCabe, chief of Air and Stream Pollution, U. S. Bureau of Mines, has accepted temporary chairmanship of a new technical committee on Sampling and Analysis of Atmospheric Pollution organized by the American Society for Testing Materials. In setting up the committee the society's board stated the committee will not consider the problems of specifying limitation of pollution nor related biological and health problems.

Control of air contamination is estimated to cost annually large sums, while in 1948 expenditures for modernizing plants for abatement of air pollution are estimated at \$50,000,000.

Brochures Are Mailed For New York Exhibit

An attractive brochure, together with contracts and specifications for the 1951 NACE Conference and Exhibition have been mailed to potential exhibitors, G. E. Seidel, chairman of the Exhibition Committee reports. Mr. Seidel also called attention to the fact that space will be allocated as nearly as possible on the basis of the return postmark on the envelope containing the exhibitor's properly executed contract and request for space, but that contracts received bearing returning postmarks prior to 12:01 p.m., October 2, 1950, will be returned to sender for re-mailing.

The Statler Hotel in New York, location of the 1951 meeting, affords exhibit facilities considered among the finest available in the country. Mr. Seidel asserted, adding he anticipates space will be at a premium.

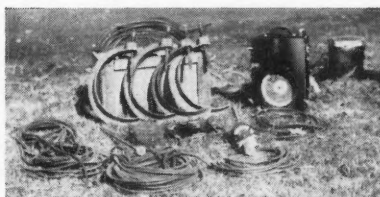
Texas-Illinois Pipeline Ground Breaking Held

Joseph J. Hedrick, president of Texas Illinois Natural Gas Pipeline Company, Houston, Texas, was among officials of the company and the states of Texas and Illinois sponsoring ground-breaking ceremonies at Wharton, Texas, August 29 for the start of the 30-inch, 1331-mile artery. The line will have an initial capacity of 305,000,000 cubic feet of gas daily. Gas collected from Texas Gulf Coast fields will be delivered to the Chicago area.

Among the officials present host to approximately 200 guests who were transported to and from Houston by the company and who enjoyed a barbecue luncheon were E. O. Thompson of the Texas Railroad Commission; James F. Oates, Jr., board chairman of the Texas Illinois company and chairman of Peoples Gas Light and Coke Company, Chicago, parent firm; William J. Murray, Jr., Texas Railroad Commission; Oscar Hewitt, Commissioner of Public Works, Chicago; Mark V. Burlingame, vice president, Texas Illinois.

Speakers Are Offered On Porcelain Enamel

Speakers on matters related to porcelain enamel are being offered gratis to associations in the United States by members of the Porcelain Enamel Institute, according to D. C. MacDonald of The Industrial News Service, 521 Oliver Bldg., Pittsburgh 22, Pa. The institute will attempt to make speakers available on request if sufficient time is given in advance for preparation of the address, and if a qualified speaker on the subject requested is available in the area from which the request originates.



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BOOK REVIEWS

NICKEL AND ITS ALLOYS. Circular 485, National Bureau of Standards, 72 pages. Supt. of Documents, U. S. Government Printing Office, per copy, 50 cents.

Systematic and accessible summary of information about nickel, including information developed at the bureau and published records of work done elsewhere. Particular attention is given to the physical and mechanical properties of nickel and its ferrous and non-ferrous applications.

Information is included on sources, extraction, recovery, refining, metallography, chemical properties, physical

properties, mechanical properties at different temperatures, casting fabrication and miscellaneous processes. Many ferrous and non-ferrous alloys are listed and their properties such as density, thermal conductivity, tensile strength, magnetic properties and corrosion resistance are discussed.

METALS AT HIGH TEMPERATURES. By Frances H. Clark. The Reinhold Publishing Co., 330 West 42nd St., New York City. 372 pages, 6 x 9, cloth. \$7.

The main theme of the text is directed to the phenomenon of flow in metallic systems, to measuring methods of flow and to the results of flow tests on many

metals and alloys. Contents include Test Methods and Equipment for Elevated Temperature, Plain Carbon and Low-Alloy Steels, Chrome Irons, Moderately Alloyed Austenitic Steels, Highly Alloyed Austenitic Steels, Cobalt Base Alloys, Nickel-Base Alloys, Non-Commercial Alloys, Manufacturing Processes, Lower Melting Alloys and Scaling. Many tables of properties and graphs related to the properties of metals at high temperatures are included. While not indexed, corrosion is covered briefly in the chapter headed "Scaling" where the mechanism of formation and destruction of thin films on metal surfaces is discussed. Effect of various alloys in reducing corrosion is considered and tables on these data are included.

STEEL CASTING HANDBOOK. Steel Founders' Society of America, 920 Midland Bldg., Cleveland 15, Ohio. 6 1/4 x 9 1/4, flexible cloth binding. 511 pages. \$4.

A 1950 revision of reference volume on steel castings first issued in 1941 and last reprinted in 1945. Information, including illustrations and tabular data, is included on types, specifications, design considerations, applications, mechanical and physical properties of steel castings. Chapter X deals with heat and corrosion resistant alloys. Chapter XII also has a section on corrosion resistance.

STRESS CORROSION OF WROUGHT MAGNESIUM BASE ALLOYS. Hugh L. Logan and Harold Hessing, National Bureau of Standards RP 2074. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 11 pages, 10 cents.

In order to determine the effect of tensile stress on the behavior of magnesium alloys exposed to corrosive media, stress-corrosion tests were made on several magnesium base alloys at two weather exposure sites and in the laboratory.

Surface Technology Course Set at N.Y.U.

Program for the Surface Technology section of the Division of General Education, New York University fall term will be as follows:

Fundamentals of Paint, Varnish and Lacquer Technology, Myron A. Coler, Adjunct Professor and Consultant in Technical Studies, New York University, September 27 to January 17.

Modern Electroplating, Edward Adler, Lecturer, New York University, September 25 to January 15.

Fifteen directors, including a president were elected at a Montreal, Canada meeting May 25 by the Air Pollution and Smoke Prevention Association of America, Dr. Hammett P. Munger, in charge of Batelle Memorial Institute's air-pollution research has agreed to act as executive assistant pending appointment of a permanent executive secretary. The purpose of the association is to foster control of atmospheric pollution and improve air sanitation.

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Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

QUESTIONS

No. 64—We should like to line a large steel hot water generator which is to operate under constant heat between 160 and 180 degrees F. A permanent lining that can be applied in the field is desired.

No. 65—An aluminum storage tank is to be installed underground. Normal backfill for such excavation is bank run gravel. However, adjacent soil may contain cinders from previous fills. Would such a tank, made either of aluminum 2S or of 3S be expected to suffer corrosion on the soil side, and if so, what type of protection should be applied?

No. 66—Are any instruments or methods available which will successfully locate an oil leak in a lead sheath power cable which normally operates at a pressure of 8 to 12 pounds? The cable is installed in a 4-inch fiber or concrete duct buried in the ground at a depth of 30 to 36 inches with manholes for joints spaced at 400- to 700-foot intervals.

Leaks usually are detected by loss of oil pressure at joints. This ties down the location of the leak to two adjacent sections but does not spot the exact location of the leak. Oil does not always appear at a duct mouth to indicate which section is leaking, nor does a cloth swab pulled through the duct containing the cable pick up oil to indicate the leaky section.

No. 67—Under what conditions in domestic waters can iron or steel become anodic to zinc in a galvanic couple?

ANSWER

A research project dealing with this subject is in progress at Case Institute of Technology under sponsorship of the American Iron and Steel Institute. Two reports dealing with this project have been published in *Corrosion*: 1. "Electrochemical Behavior of Zinc and Steel in Aqueous Media," by R. B. Hoxeng and C. F. Prutton, *Corrosion*, Vol. 5, No. 10, 330-338 (1949) Oct., and 2. Part II of the same article, *Corrosion*, Vol. 6, No. 9, 308-312 (1950) Sept. An answer to this question may be found therein.—The Editor.

No. 68—In regard to the problems of impingement attack at the inlet ends of condenser tubes: a) Is there a coating material which can be applied to

the affected region at yearly intervals to overcome the attack? b) Do plastic inserts eliminate the trouble or merely displace the impingement attack to a location beyond the insert? c) Does the practice of smoothing out the ridge between the rolled and unrolled part of the tube have merit?

No. 69—There seems to be very little data on materials to withstand varying concentrations of CO₂ dissolved in water with and without oxygen present at temperatures of 60 to 500 degrees F. Of particular interest would be data on heater tubes suitable for handling a condensate at 350 degrees F with a pH of 5 resulting from the presence of CO₂ and traces of ammonia.

We Want Your Answers To Corrosion Problems

Replies to questions under this heading are solicited by NACE. Tables, graphs and illustrations necessary for a full answer are welcomed. Address your answer to NACE Central Office, giving the question number. Early publication of answers is proposed.

Persons wishing to submit answers to questions asked under the column heading "Corrosion Problems" are requested to send duplicate copies of their answers to Central Office, 919 Milam Building, Houston 2, Texas. Names of persons submitting replies will be omitted on request.



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(Changes Through Aug. 22, 1950)

ALABAMA

BARTMESS, LEWIS C., Alabama-Tennessee Natural Gas Co., Florence, Ala.

ARKANSAS

WATSON, AMASA H., JR., Arkansas-Oklahoma Gas Co., 35 South 7th, Fort Smith, Ark.

CALIFORNIA

HANEY, CHARLES E., Electric Steel Foundry, 249 1st St., San Francisco, Calif.
STEPHENS, THOMAS O., Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.

FLORIDA

RILEY, ROBERT F., Robert F. Riley, Inc., 1100 W. Flagler St., Miami 36, Fla.

ILLINOIS

GOEBEL, EUGENE S., Motorola, Inc., Communications & Electronics Div., 4545 Augusta Blvd., Chicago 51, Ill.
McDONALD, LAWRENCE L., The Pure Oil Co., 35 E. Wacker Dr., Chicago, Ill.
PARRISH, WORDEN W., The Pure Oil Co., Box 311, Olney, Ill.
PHILLIPS, WILLIAM D., Chicago Decorating Co., 516 N. Sangamon St., Chicago 22, Ill.

MISSOURI

FILKINS, HARRY L., Middle West Engineering Co., Inc., 501 East 18th St., Kansas City, Mo.

NEBRASKA

PETERSON, CHARLES W., Natural Gas Pipeline Co. of America, Beatrice, Neb.

NEW JERSEY

BEGGS, CHARLES W., Public Service Electric & Gas Co., 80 Park Place, Room 2169A, Newark, N. J.

NEW YORK

ROSSMANN, PETER F., The Symington-Gould Corp., 2 Main St., Depew, N. Y.

OHIO

BELLER, CLARENCE J., The Cleveland Electric Illuminating Co., 75 Public Square, Cleveland 1, Ohio.
CARTER, ANTHONY J., The Pure Oil Co., Box 551, 33½ West Main, Newark, Ohio.
ROSS, ANTHONY, The Youngstown Sheet & Tube Company, Met. Lab.—Campbell Works, Youngstown, Ohio.

OKLAHOMA

BROWN, UAL J., Brown Electro Co., 17 North Dewey, Oklahoma City 2, Okla.
HANCOCK, CHARLES W., The Pure Oil Co., Box 271, Tulsa, Okla.

PENNSYLVANIA

FREDLEY, KENNETH C., Duquesne Light Co., 2101 Beaver Ave., Pittsburgh 33, Pa.
HAGERMAN, CHARLES W., Pennsylvania Salt Mfg. Co., Widener Bldg., Philadelphia 7, Pa.

TEXAS

ALCORN, I. W., The Pure Oil Co., P. O. Box 239, Houston, Texas.
DONELLY, PATRICK R., Tretolite Co., Box 1005, Midland, Texas.
DUREE, JACK T., The Pure Oil Co., Box 2107, Fort Worth, Texas.
GRANT, WHEELER H., Central Power & Light Co., Box 2121, Corpus Christi, Texas.
LEMCKE, E. M., The Fish Engineering Corp., 754 M & M Bldg., Houston 2, Texas.

WISCONSIN

SPANGENBERG, ROBERT F., Pressed Steel Tank Co., 1445 S. 66th St., West Allis 14, Wis.

WYOMING

MORRIS, JAMES L., The Pure Oil Co., P. O. Box 700, Worland, Wyo.

FOREIGN

SEGEL, KALMAN, Esso P. O. Box 667, Aruba, Netherlands Antilles.

CHANGES OF ADDRESS

(Old Address Follows New Address in Parenthesis)

ALABAMA

HAGER, KARL F., Ordnance Guided Missile Center, Redstone Arsenal, Huntsville, Ala. (Army Dept., Chief of Ordnance, Ord. Res. & Develop. Div., Fort Bliss, Texas.)

CALIFORNIA

BRIGGS, H. L., Chanslor Canfield Midway Oil Co., 4549 Produce Plaza West, Los Angeles 58, California. (Chanslor Canfield Midway Oil Co., 4549 Produce Plaza West, Los Angeles 11, California.)

KIRKENDALL, WILLIAM E., Dept. of Water & Power, 410 Ducommun St., Los Angeles, California (Dept. of Water & Power, 501 East Second, Los Angeles, California.)

SCHUHMACHER, GORDON S., Hagan Corp. & Sub. Hall Lab. & Calgon, Inc., 3931 Tweedy Blvd., South Gate, California (Hagan Corp. & Sub. Hall Lab. & Calgon, Inc., 1807 E. Olympic, Los Angeles, California.)

SMALL, RICHARD B., 427 Beverwil Drive, Beverly Hills, California, c/o S. C. Vance (California Research & Dev. Co., 200 Bush St., San Francisco, California, c/o F. W. Wyatt.)

TODHUNTER, HAROLD A., 1203 Milan Ave., South Pasadena, California. (5501 Berkshire Dr., Los Angeles 32, California.)

DISTRICT OF COLUMBIA

LOGAN, KIRK H., 1845 47th Place, N. W., Washington 7, D. C. (Cast Iron Pipe Research Ass'n, Nat'l Bureau of Standards, Washington 25, D. C.)

GEORGIA

WEEDE, J. D., Plantation Pipe Line Co., P. O. Box 1743, Atlanta, Georgia (Oakland St., Hempstead, N. Y.)

ILLINOIS

BRIGHTLY, FREDERICK C., JR., 846 So. Ridgeland, Oak Park, Illinois (Standard Galvanizing Co., 2619 West Van Buren, Chicago 12, Illinois.)

IOWA

OLSON, THEODORE W., 1420 Montgomery, Knoxville, Iowa (Natural Gas Pipeline Co. of America, P. O. Box 436, Beatrice, Nebraska.)

MARYLAND

GRIGGS, HENRY 17171 Grandview Ave., Wheaton, Silver Springs, Maryland (968 Overlook Dr., Huntington, Alexandria, Virginia.)

MASSACHUSETTS

KELLEY, HOWARD M., Chemical Fire & Rust Proofing Corp., 84½ Berkeley St., Boston, Massachusetts (KELLEY, HOWARD N., Chemical Fire & Rust Proofing Corp., 84½ Berkeley St., Boston, Massachusetts.)

MICHIGAN

CONRAD, HOWARD P., Southeastern Michigan Gas Co., Box 148, Port Huron, Michigan (Northern Indiana Fuel & Light Co. Seventh & Cedar Sts., Auburn, Indiana.)

HICKEY, ROBERT P., Socony-Vacuum Oil Co., Inc., P. O. Drawer D, Trenton, Michigan (HICKEY, ROBERT PERCY, P. O. Drawer D, Trenton, Michigan.)

REED, JOHN W., Saran Lined Pipe Co., 2415 Burdette Ave., Ferndale 20, Michigan (Saran Lined Pipe Co., 701 Stephenson Bldg., Detroit 2, Michigan.)

SHEPARD, E. R., The Hinchman Corp., Electronics Div., Francis Palms Bldg., Detroit 1, Michigan (5425 Connecticut Ave., Washington 15, D. C.)

NEW JERSEY

FAIR, W. F., JR., Koppers Co., Inc., Tar Prod. Div., P. O. Box 390, 449 South Ave. Westfield, N. J. (Koppers Co., Inc., Tar Prod. Div., 1201 Koppers Bldg., Pittsburgh 19, Pennsylvania.)

NEW YORK

BECK, WALTER, 780 Riverside Dr., Apt. 20, New York, N. Y. (1020 West North St., Bethlehem, Pa.)

OHIO

RONDEAU, H. S., 2865 Coventry Rd., Shaker Heights 20, Ohio. (610 Wayland Ave., Kenilworth, Ill.)

OKLAHOMA

COATS, SANFORD C., 1244 Staton Dr., Oklahoma City, Okla. (Tnemec Co., 1244 Staton Dr., Oklahoma City, Okla.)

RODDY, DAVID F., The Texas Pipe Line Co., P. O. Box 2420, Tulsa, Okla. (Texas-New Mexico Pipe Line Co., Box 1510, Midland, Texas.)

PENNSYLVANIA

BOWDEN, RAYMOND C., JR., National Tube Co., Research Lab., 327 Craft Ave., Pittsburgh 13, Pa. (Penn. & Braddock Ave., Pittsburgh 8, Pa.)

SPENCER, S. F., Res. & Div. Sec., Keystone Shipping Co., 1000 Walnut St., Philadelphia 7, Pa. (Res. & Dev. Sec., Keystone Shipping Co., 1015 Chestnut St., Philadelphia 7, Pa.)

(Continued on Page 13)

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Coatings and Systems Limiting Formation Or Providing Removal of Ice Being Sought

Ice formations on Naval vessels and aircraft have been a source of considerable difficulty. To determine whether industry has available coatings systems which will eliminate the difficulties, the Bureau of Ships, Aeronautics, and Ordnance, Department of the Navy, have stated for the benefit of interested concerns their requirements and those of the currently available types of such systems which they feel might be used with success.

This statement came as a result of a survey of the industrial availables and potentials made by a Task Committee of the National Security Industrial Association working under the chairmanship of George Diehlman, National Lead Company, with representatives of these bureaus. That group, in addition to making a comprehensive report and analysis of the problem, classified various types of systems available today. That classification includes freezing point depressants, parting compounds, adhesion depressants, durable coatings exhibiting low ice adhesion, thermal systems, mechanical systems, nucleated surfaces and combinations of these systems. Any concerns interested in proposing candidate products, systems, or combinations thereof which they feel may meet these requirements, are asked to advise the National Security Industrial Association, 110 William Street, New York 7, New York.

I. Bureau of Ordnance

The Bureau of Ordnance is interested in obtaining or developing a system which will be effective at least six months. As it will not be effective as

long as the equipment to which it is applied, it should be applicable, under field conditions by brushing or spraying. Any coating should be clear and transparent and be able to be pigmented to match the color scheme of the equipment to which it is applied. The system must combat all types of ice, not only that formed by flying sea spray and freezing rain but also rime due to super-cooled droplets. The minimum temperature ranges involved are minus 20°F for shipboard equipment and minus 65°F for airborne equipment.

The types of equipment to which the coating will be applied have no excess heat or energy available for ice removal. The additional weight of equipment used for ice removal is undesirable. With respect to the time element involved, no standard rate of ice formation or thickness of ice which can be tolerated at one time has been adopted. It is suggested, however, that the following values be used: maximum rate of ice formation, 8 oz. per hour; maximum thickness of ice tolerated at one time, 3 inches.

The Bureau is specifically interested in the following types of systems:

- i) *Thermal-Electrical-Mechanical*: This system would employ electric heat to melt an interfacial ice layer, thereby permitting removal of the complete crust by vibration or wind in controlled cycles, depending upon the icing rate.
- ii) *Mechanical plus Durable Coatings Exhibiting Low Adhesion*: In general, this would be a coating having low ice adhesion properties. Mechanical means would be used for removing the ice from the surface involved.
- iii) *Transparent Anti-icing Coating for Plexiglass or Similar Windows*.
- iv) *Parting Compounds*: The Bureau has established no standard test procedure. Cold room facilities are, however, available at the Naval (Continued on Page 14)

New Members—

(Continued from Page 12)

TEXAS

- BLILIER, ROY K., Service Engineers, Inc., P. O. Box 11068, Fort Worth, Texas. (Service Engineers, Inc., 709 1st National Bank Bldg., Fort Worth, Texas.)
- GROSS, LEWIS, Taylor Refining Co., 805 North Third St., McAllen, Texas. (Taylor Refining Co., P. O. Box 4067, Corpus Christi, Texas.)
- HEYER, B. F., Central P. & L. Co., P. O. Box 2121, Corpus Christi, Texas. (New corporate representative replacing George A. Mills, Central P. & L. Co., 120 North Chaparral St., Corpus Christi, Texas.)
- HOLT, JAMES B., 625 W. Centre St., Dallas, Texas. (International Minerals & Chemical Corp., Carlsbad, N. M.)
- LINGLE, ROBERT J., 4503 Merrie Lane, Belaire, Texas. (Room 305, Shell Bldg., Houston 2, Texas.)
- McMILLAN, W. A., JR., 710 Anita St., Houston 6, Texas. (Route 9, P. O. Box 900, Houston, Texas.)
- SMITH, TRACY E., National Tank Co., 1101 Magnolia Bldg., Dallas, Texas. (National Tank Co., Box 1387, Odessa, Texas.)
- WADE, O. W., R.R. 4, Box 616, Houston, Texas. (Transcontinental Gas Pipe Line Corp., 905 M & M Bldg., Houston, Texas.)
- WARING, W. H., Johns-Manville Sales Corp., P. O. Box 255, Houston 1, Texas. (Johns-Manville Sales Corp., P. O. Box 8217, Houston 4, Texas.)

WEST VIRGINIA

- WIEGERS, CONRAD L., Allied Services, Inc., Spring & Bullitt Sts., Charleston, W. Va. (Combustion Equipment & Insulation Co., 2301-5 Pittsburgh St., Cleveland, Ohio.)

FOREIGN

- VAN RYSELBERGHE, PIERRE, c/o Prof. R. Piontelli, Politecnico di Milano, 32 Piazza Leonardo da Vinci, Milano (132), Italy. (Dept. of Chemistry, University of Oregon, Eugene, Ore.)

NEW NACE CORPORATE MEMBERS

CLEVELAND ELECTRIC ILLUMINATING CO.

Cleveland, Ohio
Clarence J. Beller, Representative

COMMERCIAL SOLVENTS CORP.

Terre Haute, Ind.
Richard S. Egly, Representative

GLOBE OIL & REFINING CO.

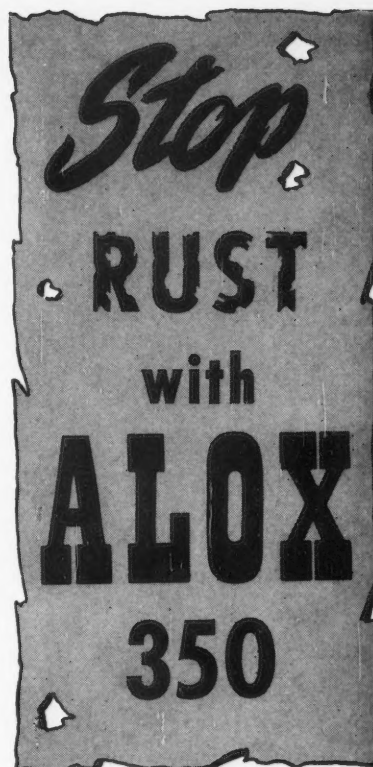
Lemont, Ill.
J. M. Lawson, Representative

ALUMINUM LABORATORIES, LTD.

Kingston, Ontario, Canada
H. P. Godard, Representative

MALLINKRODT CHEMICAL WORKS

St. Louis, Mo.
C. W. Swartout, Representative



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Coatings and—

(Continued from Page 13)

Gun Factory and the Naval Ordnance Laboratory which could be utilized for testing candidate products. Additional tests could be conducted on naval vessels engaged in cold weather cruises.

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THE LARGEST ORGANIZATION OF ITS KIND GIVING SAFE MAINTENANCE AT LOW COST

II. Bureau of Ships

The Bureau of Ships is primarily interested in developing a system which will be effective for at least six months. As it will not last as long as the equipment to which it will be applied, consideration must be given to the fact that it will be renewed and maintained by relatively inexperienced personnel operating under field conditions. Any coating should be either clear or colored to harmonize with haze grey systems now in use and should have no harmful effect on such systems.

There will be no source of excess heat or energy available to assist in keeping the surfaces free of ice. Additional equipment for removal of ice may, however, be included in the systems. The minimum temperature range in which the equipment will operate is minus 20°F. The system must be able to combat ice formed primarily by freezing rain or sea spray and snow. Optical properties are not a consideration in the development of the system.

Of the catalogued systems, the Bureau has evidenced an interest in primarily parting compounds and adhesion depressants. A combination of hydrophobic paint surfaces with a parting compound is another area of interest. A combination of such systems with supplemental mechanical means for ice removal may be considered. Test facilities are available for promising materials.

III. Bureau of Aeronautics

The Bureau is interested in a system for application to aircraft which will be effective for approximately thirty days. The coating should be capable of being applied by brush or spray either in the ship or under less ideal conditions. The use, therefore, of equipment readily available at shore bases or on carriers, such as spray guns or brushes, is preferred to special types of application equipment. It should be capable of application over lacquer or enamel coatings with no deleterious effects to the finishes. If a durable coating is applied initially, it should be capable of being pigmented in various colors. Any freezing point or adhesion depressant used, however, should be clear or semi-transparent.

This Bureau is particularly concerned with the problem of the removal of ice formed by flying sea spray and freezing rain, in the temperature range of -15° to -32°F for carrier-based aircraft and down to -65°F for shore-based aircraft. For aircraft in flight, ice removal in the neighborhood of 25° to 32°F. is of paramount importance.

The time element in ice-removal is very important and, for carrier or shore-based aircraft, the Bureau requires the removal of 1/4 inch of ice in ten minutes (maximum). For aircraft in flight, this thickness of ice cannot be tolerated and the ice must be removed before it reaches a thickness of 1/16 inch.

The Bureau is particularly interested in the following types of systems:

- i) Freezing point depressants
- ii) Durable coatings exhibiting low ice adhesion
- iii) Adhesion Depressants

An efficient combination of the above systems would be of interest. For example, a durable coating exhibiting low ice adhesion which might be applied to the exterior surfaces of aircraft and over which a freezing point or adhesion depressant might be applied to improve the ice removal characteristics of the coating. Such a durable coating might be of a semi-porous or absorptive nature which would retain the freezing point or adhesion depressant, thus rendering it effective for a longer time. The Bureau is also interested in any improvements of modifications of the thermal and mechanical systems currently employed on Naval aircraft: such as, electric windshield defrosters, exhaust gases for leading edge deicing, and deicer boots.

Manuscripts Approved For Early Printing

Manuscripts approved for publication received at Central Office NACE include:

A Method of Selecting Protective Coatings for Offshore Drilling Structures by Jack P. Barrett, Stanolind Oil and Gas Co., Tulsa, Okla.

The Use of Cathodic Protection in Conjunction With Paint Coatings by W. L. Crosby, Consolidated Edison Co. of New York.

A Study of Metals for Use as Permanent Anodes in Water Tank Cathodic Protection Systems by A. L. Kimmel, University of Florida, Gainesville.

Some Applications of Electrochemical Thermodynamics by Marcel Pourbaix, University of Brussels, Belgium.

Design of Anode Systems for Cathodic Protection of Underground and Water Submerged Metallic Structures by E. R. Shepard, Hinchman Corp., Detroit, Mich., and Henry J. Graesser, Jr., Office of the Chief of Engineers, Department of the Army, Washington, D. C.

News about the activities of organizations anywhere in the world engaged in corrosion mitigation are welcomed for use in the news section of CORROSION.

Advance notices of meetings of corrosion interest should be sent to CORROSION in sufficient time to permit publication in an issue distributed before the meetings are held.

NEW PRODUCTS—Materials—Service—Literature

Crocker-Wheeler totally enclosed fan cooled electric motors are used at locations where their characteristics are valuable in the Walworth Greensburg, Pa., plant, according to a story in the summer issue of "Powerfax," a publication of the Elliott Company, Jeanette, Pa.

Universal Flexible metal hose of all types, as well as tubing and fittings for conveying solids, fluids or gases at elevated pressures and temperatures are described in a 12-page catalog No. U-101 by Universal Metal Hose Company, 2133 South Kedzie Ave., Chicago 23, Illinois.

Flame-Spraying polyethylene from 1/32-inch to 1/4-inch thick on tanks and processing equipment assures a homogeneous coating, according to Houghton Laboratories, Olean, New York, which has developed a process for the flame spraying of this material. The firm will coat existing equipment or supply coated equipment or personnel and equipment for field applications.

Doctor Blades used in pulp and paper making industry are described in a new bulletin by International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. Information of general interest to chemical and other industries also is included.

New Sales Agencies for Dampney Co. of America, Boston, are Boiler Supply Co., 440 Chester St., Nashville, Tenn., and R. E. Mundy Co., 1520 Cleveland S.W., Roanoke, Va. In Mexico Dampney products are to be distributed by Consultores y Abastecedores Industriales, S. A., Dolores 17-301, Mexico, D. F.

Industrial Filter and Pump Manufacturing Co. has moved to 5900 Ogden Ave., Chicago 50, Ill.

Calgon, Inc., has moved its Los Angeles, Cal., office to 3931 Tweedy Blvd., South Gate, Cal.

Illium Corporation is the new name of Burgess-Parr Company, Freeport, Ill.

Sensitive Research Instrument Corp., 9-11 Elm Ave., Mount Vernon, N. Y., has issued a technical data sheet on its new Duplex Electrolysis Instrument.

Dipped Rubber latex films to protect metal parts in shipment are recommended by the Natural Rubber Bureau, 1631 K Street N. W., Washington 6, D. C. An inhibitor is being used to prevent the water in the latex compound from attacking the metal. "Rubber Developments," a pamphlet on new uses for rubber, is available on request.

BX White Enamel, a product of Prufcoat Laboratories, Inc., 63 Main Street, Cambridge, Mass. may be applied to masonry, metal and wood surfaces, even when damp to provide a protective coating which stays white under the most difficult corrosive conditions, manufacturers say. The paint is the result of over 10 years of research, and is said to be equal to other paints in the Pruf-

coat line in corrosion resistance. Full details are available in a folder titled "BX White Enamel Stops Corrosion."

Tank Insulation using on hot surfaces 85 percent magnesia, rockwool or glass fibers to gain as much as 250 degrees surface differentials, and cork and plastic foam materials on cold storage is applied by Nicholson and Galloway, 426 East 110th St., New York 29, N. Y. Insulation is applied between channel sections welded to the tanks and pro-

tected by an outer layer of sheathing which may be aluminum, asbestos or a non-corrosive metal.

"One Minute Tests" for water hardness by Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa., are described in Bulletin 1 RE 50. Procedures, reagents and equipment are pictured and described. Accuracy to within one ppm is claimed. Tests may be used to determine total hardness, hardness due to calcium alone or to magnesium alone.

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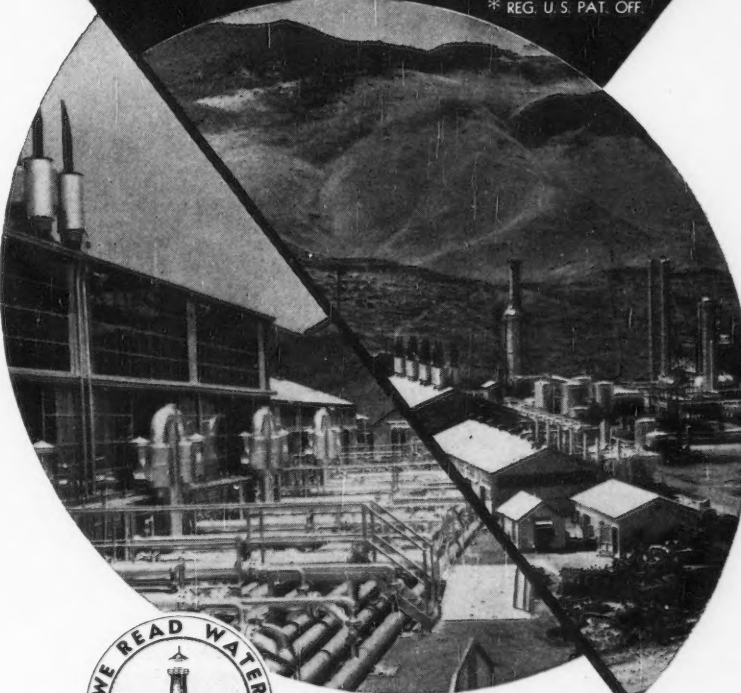
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NEW PRODUCTS

Graphite and Water is being used as a substitute for tar coatings in ingot molds at the steel and tube division of Timken Roller Bearing Company's to eliminate smoke and fumes.

Rust and Corrosion resistant Monel sponges are being manufactured by Kleenette Manufacturing Co., 1269 W. North Ave., Chicago 22, Ill.

Small and Uniform grain structure 14S-T6 aluminum produced by special process at the Harvey Machine Co., Inc., Los Angeles, showed no significant distortion after machining, manufacturers claim. The fine, completely recrystallized grain structure with uniform grain size distribution throughout the material is believed to be the principal reason. Previously distortion caused by non-uniform residual stresses from heat treatment associated with a heterogeneous crystal structure consisting of elongated grains varying in size has been a disturbing problem in the production of long and heavy extruding spar caps used in airplane fabrication. It was found the stresses varied in magnitude across the fibers and as layers of fibers were removed in machining, stress relief occurred, causing movement.

"Dresser-Bond" bonding kits consisting of 50 preformed bonds, welders, flint gun, flash powder, metal disks and coating compound for completing 50 bonds are being offered by Dresser Manufacturing Division, Bradford, Pa.

ACP Phosphate Coating Chemicals and Processes is the title of a new 12-page coating bulletin issued by American Chemical Paint Corp., Ambler, Pa. The bulletin contains data related to the company's products for use in paint-bonding, of steel, zinc, and aluminum with spray, brush and immersion processes; rust proofing, and other information. Copies are available on request.

"Scotch" Electrical Tape No. 22 is recommended by electrical engineers, to protect buried pipe against corrosion, according to Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul, Minn., which has issued a folder describing recommended uses of the material for this purpose. The 10-mil black polyvinyl chloride-backed material has a tensile strength of 30 lbs. per inch of width, elongation at break of 125 percent, excellent resistance to sunlight, ageing, water, acids, alkalis and good resistance to alcohols, oils, bacteria and fumes, manufacturers say.

Fansteel Tungsten and Molybdenum is the title of a 24-page illustrated booklet on these two metals published by the Fansteel Metallurgical Corp., North Chicago, Ill. The booklet covers in text and tables metallurgy, physical, mechanical and chemical properties, uses and applications, fabricating techniques and available forms. Seamless molybdenum tubing and parts with protective coatings for high temperature service in air are described.

Dutch Boy Metal Painting Handbook, second printing, has just been made available through National Lead Company, 105 York Street, Brooklyn 1, N. Y. The book contains information on metal protective paint, surface preparation, conditions for application, paint systems and detailed formulas on anti-corrosive and finish coat paints.

Totrust and Totalume coatings, products of Wilbur & Williams Company, Greenleaf and Leon St., Boston 15, Mass. are useful for painting rusted metal surfaces where some moisture remains, manufacturers say. The coatings displace moisture from pits to surface of coating where it evaporates. Numerous other coatings, including specialized finishes for concrete floors, outside masonry structures and other surfaces are included among the materials made by this firm.

Emulsifier STH, an inhibitor mentioned in an article by K. F. Hager and M. Rosenthal "Rust Preventing Pickling Inhibitor" in the July, 1950 issue of *Corrosion* magazine is being manufactured by General Analine & Film Corp., Central Sales Development Dept., 22 Center Square, Easton, Pa. Characteristics of the material, prepared in an effort to duplicate the German "Emulphor STH," are excellent emulsification in water, low sensitivity to water hardness salts, specific affinity for metals resulting in high lubrication and cooling efficiency and excellent rust inhibition. It is suggested for use in metal drawing, drilling, milling and grinding operations. Pilot plant production now under way makes possible delivery of small quantities (8, 40 and 450 pound lots at \$1.02 for first two quantities and 92 cents for last quantity per pound) for test purposes by firms interested in determining whether the material meets their requirements. General Analine will supply recommended formulations and some data on research. One-half pound complimentary samples also are available without cost.

Nickel-Chromium Steels, The International Nickel Co., Inc., New York, Bulletin NS-2 gives full tabular and graph data on Type 3100 series nickel-chromium steels, including warehouse sources of supply and priority, trade-named steels.

Higher-Resistance to corrosives, tensile and tear strength than natural rubber is claimed for a plastic-impregnated "Plastiglov" made by American Rubberizing Co., 617 11th Ave., Minneapolis, Minn.

"Who Knows—And What" a reference book on personal specialties in occupational fields is being prepared for a second edition by A. N. Marquis Co., 210 East Ohio St., Chicago, Ill., publishers of Who's Who in America.

"ABC's of Welding High Tensile Steels," a booklet, has been issued by the Arcos Corp., 1500 South 50th St., Philadelphia 43, Pa.

Pylumin Process, a surface preparation process for aluminum involving the use of a single powder in a heated immersion tank, which has been in use by the Pyrene Manufacturing Co., Metal Finishing Division, 10 Empire St., Newark 5, New Jersey, in the United States and Great Britain now is being offered to others. The company claims no special pre-cleaning of parts to be immersed is necessary if the amount of dirt and grease on parts to be processed is not excessive. It also is claimed the process is adaptable to either large or small scale production and can be used on widely varying products of aluminum and aluminum alloy.

Easier Fabrication of multiwall polyethylene-coated kraft stock bags is claimed through use of Poly-Lok, a seam adhesive manufactured by National Adhesives, 270 Madison Ave., New York City 16.

Plastikon Rubber Putty, recommended by B. F. Goodrich Co., Akron, Ohio, for glazing and sealing where vibration, corrosion or moisture exists is described in catalog sheet 9765 available on request.

Nox-Rust 310-AC is suggested by the manufacturers, Nox-Rust Chemical Corporation, 2423 S. Halstead St., Chicago 8, Ill., for protection of metal parts during manufacture, storage and transit. A bulletin describing the product says the material removes fingerprints and displaces moisture.

Bakelite Polyethylene, a 24-page booklet available from Bakelite Division, Union Carbide and Carbon Corp., 300 Madison Ave., New York 17, N. Y., lists some of the unique characteristics of this material, gives its history, available forms, methods of fabrication and includes tables of characteristics.

Glass Fibers, Inc., will manufacture flotation wool for the United States Navy at a newly activated plant at Defiance, Ohio.

Dekoron Instrument Tubing, flexible copper tubing with an extruded coating of either polyethylene or vinyl, offered in standard sizes of 1/4-inch and 3/8-inch OD, is suggested for use in corrosive environments. Other than standard materials may be supplied with either coating, manufacturers Samuel Moore & Co., Mantua, Ohio report.

Swagelok fittings, consisting of two ferrules and a threaded chuck inside the nut clinch tightly around the tubing wall and provide a leak-proof seal for instrument tubing, according to the W. N. Gates Co., 1621 Euclid Ave., Cleveland 15, Ohio. The fittings are made for use with aluminum, brass, copper, stainless steel, steel and plastic tubing.

Reprints of "Corrosion Tests in the Processing of Soap and Fatty Acids," by J. F. Mason, Jr., and W. Z. Friend of The International Nickel Co., New York are available from the firm, 67 Wall Street, New York 5, N. Y. The article, 16 pages in length, was published originally in *CORROSION*, November, 1949 issue.



Yes... an oil seal that's tailor-made to *resist* corrosion

● If corrosive conditions are shortening the life of your oil seals, the Johns-Manville Clipper Seal should provide a practical solution to your problem.

Here's why: The Clipper Seal's molded body is entirely non-metallic and is, therefore, unaffected by most forms of corrosion. To meet special conditions, the garter spring which holds the lip in contact with the shaft can be furnished in various corrosion-resistant metals . . . or *Clipper Seals of special design that do not require garter springs may be used.*

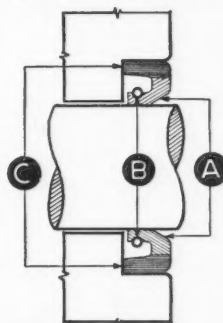
The one-piece, concentric molded design of Clipper Seals also assures a number of other advantages. The hard, tough outer heel of the Clipper Seal is resilient enough to conform even to a slightly out-of-round cavity. And the soft, pliable inner lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

Clipper Seals are quick and easy to install, may be had in split or endless types, are available in sizes

from 1/4" I.D. up to 66" O.D. If you have a special sealing requirement, or wish to consult about a special design problem, write Johns-Manville, Box 290, New York 16, N. Y.



Here's how *Clipper Seal* works:



The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns - Manville

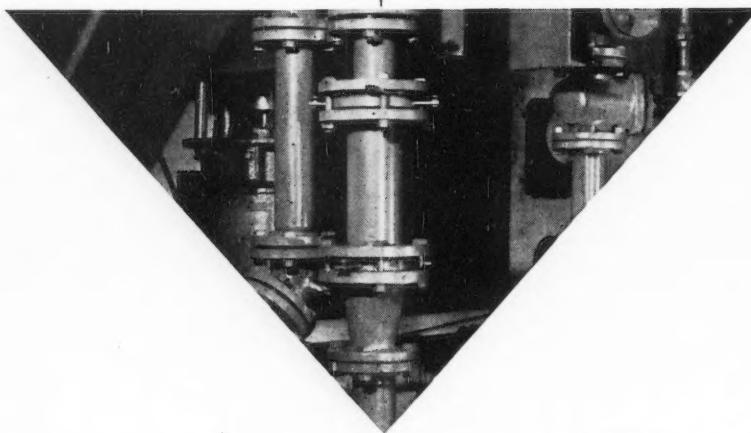
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valves, flanges, reducing flanges, flanged fittings, gaskets and fittings with union ends.

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SARAN LINED PIPE**DOW****product****PERSONALS**

Armon H. Bost, vice-president and general manager of Midwestern Engine and Equipment Co., Tulsa, Okla., returned to active army duty September 15. He will maintain his connection with Midwestern and his two partners will continue operation of the nation-wide activities of the firm. O. E. (Ted) Murray and Jack Glandon, among the original organizers of the firm, who with Mr. Bost bought out all major stockholders, expect Mr. Bost to return to the company at a later date.

James A. Tyvand has joined Ebasco Services Incorporated as a member of the consulting engineering staff.

R. J. Wiseman has been named vice-president and chief engineer of Okonite Company, Passaic, N. J. He joined the company in 1922 as research engineer. He is a Fellow of the AIEE, past president of the Insulated Power Cable Engineers Association, and member of a number of other technical organizations.

Robert H. Steiner has been named research coordinator of Atlas Mineral Products Co., Mertztown, Pa.

E. H. Henderson has been elected vice-president of The Rosson-Richards Co., Inc. and The Rosson-Richards Processing Co., Inc.

Orlin W. Lyons, for seven years Shreveport, La. district manager for Dowell Incorporated has been named on the staff of Brazos Oil and Gas Co., with headquarters in Houston, Texas. **Floyd Carr**, formerly with Dowell at Tulsa replaces Mr. Lyons at Shreveport.

Morris Rosenthal, formerly with General Electric Co., at El Paso, Texas, has been named assistant city clerk of El Paso, according to a news story in the July 20 issue of the El Paso, Texas, Herald-Post. He is a member of NACE.

R. A. Dittbrenner has been named Eastern representative by the Carboline Co., 7603 Fortieth Blvd., St. Louis, Mo. He also will handle advertising and sales promotion for the company's products.

William F. McConnor has been elected executive vice-president of National Tube Company, U. S. Steel subsidiary.

Marshall E. Parker has opened his offices as a consulting corrosion engineer for corrosion surveys and cathodic protection at 2023 Jean St., Houston, Texas.

Lester R. Sagar has been named process manager of Dearborn Chemical Company, Chicago, to supervise production planning and development of process equipment.

Bjorksten Research Laboratories, Inc., has purchased a 168-acre tract near Madison, Wis., for the development of new testing units, scientific equipment and laboratory buildings.



Corrosion Abstracts

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GENERAL

• Miscellaneous

1.1, 6.5

Non-Corrosive Soldering Flux Paste for Universal Application. John A. De-Rosa, J. Mitchell Fain, and Chester A. Snell, Foster D. Snell, Inc., New York, N. Y. (First Quarterly Progress Report; U. S. Dept. of the Army, Contract No. W36-039-sc-38216) 1949, Apr.

An investigation of various paste media for preparing a noncorrosive resin-paste flux showed the best to be a metallic soap gel in a hydrocarbon solvent. Teglac-127 and -128 resins and, to a certain extent, Polypale resin (Rosin Dimer) were not adaptable to this medium. Other resins investigated included rosin, Nuroz (a partially polymerized rosin), and Staybelite.

With aluminum stearate as the soap,

both rosin and Nuroz gave promising paste fluxes. Nuroz pastes showed a greater fluxing activity and only slightly greater corrosiveness than rosin in comparable compositions. The best Nuroz-soap paste consisted of 42% Nuroz, 6% aluminum stearate, 2% hexadecyltrimethylammonium bromide, and 50% tetrahydronaphthalene. This composition may be suitable also for use in cored solder since it can be liquefied by heat.

Of several plasticized resin fluxes, such as commonly used in core solder, two were outstanding. The first, the solid equivalent of a previously developed composition, consists of 67.7% Teglac-128, 2.6% ethylhexadecyltrimethylammonium bromide or hexadecyltrimethylammonium bromide, 2.6% glycol, and 27.1% amyl acetate. The second comprised 77.6% Nuroz, 3.1% ethylhexadecyltrimethylammonium bromide or hexadecyltrimethylammonium bromide, 3.1% rosin oil, and 16.2% turpentine oil.

The evaluation of fluxing activity was restricted to the spreading-drop test, using copper as base metal and 50/50 tin-lead solder. Flux corrosiveness was determined visually after exposure of flux-coated copper to 130° F and 95-100% RH. A corrosion-current test for evaluating flux corrosiveness is being developed.

PDC Comment: The authors have developed an active, non-corrosive soldering flux for bright and slightly oxidized copper, brass, and tin plate. It consists of an alcoholic solution of 25% Teglac-128 resin, 1% ethylhexadecylammonium bromide, 1.2% glycerol, and 10% amyl acetate. (Non-Corrosive Soldering Flux for Universal Application). (39) 1, June, 1948. PDA 6: Met 65, C-650 (8).—PDA.

• Reviews

1.3, 6.2

Information on Rusting and Rust Protection of Iron and Steel, 1946 and 1947. (In German.) Heinrich Steinrath. *Stahl und Eisen*, 69, 528-531 (1949) July 21.

Presents the first part of a review of the literature. 52 ref. (To be continued.)

• Organized Studies

1.7, 5.10

Work in Progress at the Chemical Research Laboratory, Teddington. *Electroplating*, 2, No. 8, 525-529 (1949) Aug.

Discussion of work includes benzoate/nitrate inhibitors in heat exchange systems and in temporary protective coatings, electrochemical studies of protective coatings on metals, accelerated corrosion tests, study of protective films and chromatographic analysis.—INCO.

1.7, 2.2, 2.3

Corrosion Testing Facilities at Kure Beach, North Carolina. I. M. Parker. *Corrosion*, 5, No. 9, 303-307 (1949) Sept.

Brief well-illustrated account of work

being carried out at this corrosion testing station. Plant includes an 80-ft. atmospheric spray testing rack, an 800 ft. atmospheric test site, and a large seawater test basin whose walls are steel piling on which corrosion tests are being carried out. Other work in progress includes use of zinc and magnesium anodes for cathodic protection, anti-fouling, cavitation, and various other problems. This station has been developed by the International Nickel Company.—BNF.

• Fundamentals

1.8

On the Size and Distribution of Reacting Patterns, Interference Patterns, or "Active" Patterns on Metal Surfaces. (In German.) Otto Erbacher. *Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie*, 52, 54-67 (1949) Mar.

Arrives at certain conclusions based on previously determined data on the electrochemical and adsorptive behavior of metal surfaces. Photographs show the effects of solvents on sheet metals. Data are tabulated and graphed. 13 ref.—BLR.

1.8, 3.6

On the Topochemistry and Kinetics of Corrosion Processes. W. Machu. *Archiv. Metallkunde*, 3, No. 1, 1-7 (1949).

The kinetics of corrosion processes are discussed, and it is shown that the essential factors affecting the rate of corrosion and the resistance to corrosion are the stability and magnitude of the cathodic surfaces present. A relationship is established showing the alteration of cathodic surfaces with time. The rate of corrosion of metal surfaces covered by corrosion products: 1) does not depend on the conditions at and the area of anodic surfaces, as has previously been assumed, but is proportional to the number and area of the cathodic surfaces which exist, and 2) is influenced by the properties of the corrosion products, i.e., their stability and, more particularly, their conductivity, the latter determining the amount of oxygen depolarization or hydrogen-ion discharge which occurs at the cathodic surfaces. Various corrosion processes are considered, including the formation of metal-oxide films, oxides, hydroxides, carbonates, sulphates, chlorides, etc., of metals and non-metals, and particularly the formation of phosphate films on metals.—MA.

1.8, 5.9, 5.3

The Kinetics of Coating Phenomena, Especially That of the Phosphating Process. (In German.) W. Machu. *Archiv. Metallkunde*, 3, 203-208 (1949) June.

Develops a general rule for the rate of reaction in the formation of protective metal coatings and shows that the rate of film formation at the cathode is proportional to the area of the anode. Applies the rule to 11 specific examples. 11 ref.—BLR.

1.8, 2.3

The Adsorption of Metal Ions on Metal Surfaces. (In German.) Otto Erbacher, Wilfrid Herr, and Malene Widemann. *Zeitschrift für Naturforschung*, 3a, 637-645 (1948) Dec.

Radioactive indicators were used to determine the adsorption behavior of different metal ions on solid metals and liquid mercury. The method is fully described and the results evaluated. Includes diagrams and graphed and tabulated data. 14 ref.—BLR.

1.8, 3.6

Redox Recipes. I. Reaction Between Ferrous Iron and Peroxides. General Considerations. A. I. Medalia and I. M. Kolthoff. *J. of Polymer Science*, 4, No. 3, 377-397 (1949).

Various mechanisms which have been proposed for the reaction between ferrous iron and hydrogen peroxide are reviewed. The determination of H_2O_2 by reaction with ferrous iron, if carried out in the presence of various organic compounds (termed promoters) gives incorrect results, due to induced oxidation of promoters; other compounds, termed suppressors, reduce the extent of this oxidation. Importance of these considerations in the determination of organic hydroperoxides is pointed out. The reaction between H_2O_2 or organic peroxides and ferrous iron is an example of redox polymerization. 53 ref.—BLR.

1.8

The Oriented Growth of Cuprous Oxide on Spherical Copper Single Crystals. (In German.) Erich Menzel. *Zeitschrift für Anorganische Chemie*, 256, 49-64 (1948) Mar.

The orientation of Cu_2O films on spherical mono-crystals of copper was studied as a means of investigating physical and chemical phenomena on crystal surfaces, by optical and X-ray methods. Includes photographs, diagrams, and graphs. 22 ref.—BLR.

1.8

Oxide Films on Metals—Experimental Determination of Rate of Growth. *Metal Ind., Lond.*, 72, 310 (1948) Apr. 16.—BL.

1.8, 6.3

Influence of the Order-Disorder Transformation on the Chemical Activity of β -Brass. (In French.) Georges Nury and Hubert Forestier. *Comptes Rendus (France)*, 229, 123-124 (1949) July 11.

The above was investigated for β -brass containing 48% zinc up to about 460° C, by determining the change of rate of oxidation with temperature. Results for both α - and β -brass are charted.—BLR.

1.8, 6.2

An X-Ray Study of the Scale Formed on Iron Between 400 and 700° C. O. A. Tesche. ASM Preprint No. 12, 1949, 9 pages.

Scales formed on oxidation for 15 min. over the above temperature range were studied. It was found that Fe_3O_4 is the only oxide formed up to 625° C. At 650-700° C a double-layered scale was found, FeO lying next to the metal with an overlay of Fe_3O_4 . 20 ref.—BLR.

1.8

Certain Aspects of Reactions Between a Solid Phase and a Liquid or Gaseous Phase. (In French.) F. Trombe. *Bull. de*

la Société Chimique de France, 1949, D213-D217, Mar.-Apr.

Indicates the importance, from the practical point of view, of the ratio between the volume of solid products which may exist in the initial and final steps of a reaction. Depending on the value of this ratio, that is above or below unity, the solid phase formed protects or does not protect the initial phase. Describes application of this theory to oxidation of metals, to the attack of silica on aluminum, and in general to the protection of metal by oxide films.—BLR.

1.8, 2.3, 3.6

The Galvanic Cell Effect of Dissolving Iron in Hydrochloric Acid—II. (In German.) K. Wicket and H. Pilz. *Archiv. für Metallkunde*, 3, 214-221 (1949) June.

Describes experiments made to produce galvanic iron-electrolyte vs. copper cells in metal powders and to measure the rate of solution of these powders in hydrochloric acid. Data are graphed and tabulated.—BLR.

TESTING

• General

2.1, 5.4

Paint Testing Again. N. R. Fisk. *Paint Tech.*, 14, No. 158, 51-4 (1949).

The need to examine laboratory tests critically so that they shall bear relation to practice is discussed with particular reference to paint application and accelerated weathering apparatus. Thus, fog may have an adverse effect on paint films, and a recent paper by Gay underlines the importance of water in paint breakdown. The testing of paint on thin wood and metal may bear no relation to practice where thick wood and steel girders have to be painted. It is felt that American procedure has been followed too closely. Thus the present requirement for the speed of the drum in accelerated weathering apparatus would appear too rapid—one revolution in 2-3 hrs. is suggested.—RPI.

3.2, 2.1

Determination of Microstructure of Welds of Stainless Steel on Basis of Microhardness. B. I. Medovar & A. E. Asnis. *Zavodskays Lab.*, 15, No. 5, 570-571 (1949).

Application of microhardness test to determination of susceptibility of stainless steel welds to intergranular corrosion. Results of microhardness measurements on welds of 18-8 steel, formula used for calculation of hardness number and advantages of test over currently used test methods are given. 7 references.—INCO.

2.1, 5.4

Modified Nomograph for the Evaluation of Paint Exposure Panels. J. R. Rischbieth, H. A. Laurie & K. R. Bus-

Abstract Section
Style Outlined

For ease in locating reference data, CORROSION uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

PRIMARY SOURCES OF ABSTRACTS PUBLISHED IN CORROSION

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 500 5th Ave., New York 18, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BLR—Battelle Library Review, Battelle Memorial Institute Library, 505 King Ave., Columbus, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W2 1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England, 4 Grosvenor Gardens, London SW 1, England.

ME—Marine Engineering, The Institute of Marine Engineers, 85/88 The Minories, London E. C. 3, England.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

PDA—Prevention Deterioration Abstracts, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers, 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France, 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

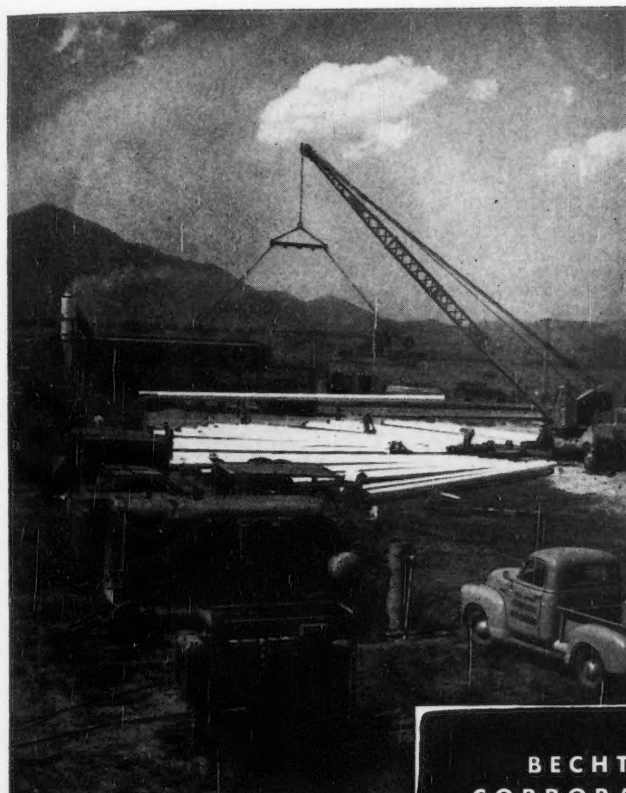
TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

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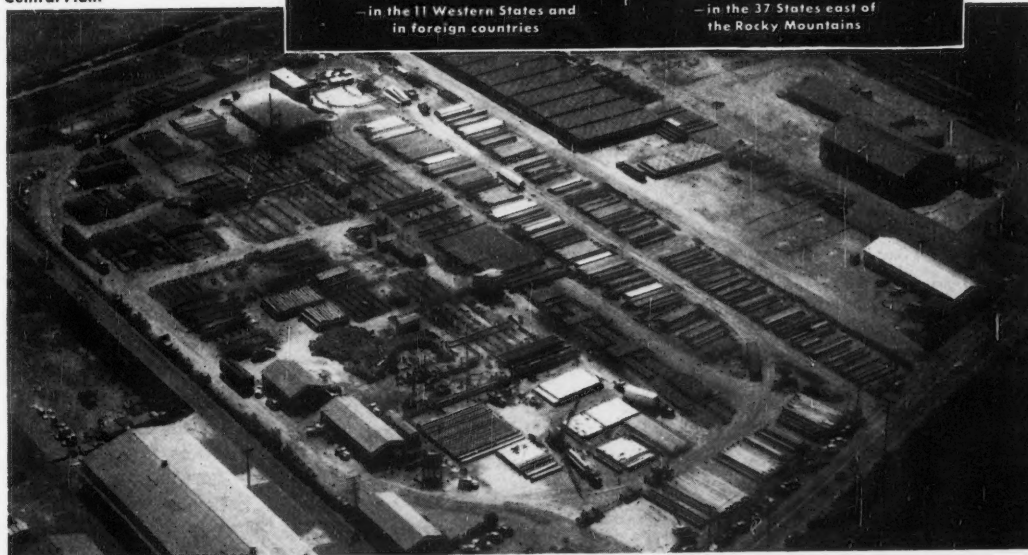
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The elimination of the air and vapor space practically stops corrosion on the underside of the roof and the inside of the tank shell above the liquid. The corrosion of the tank bottom is also reduced materially because relatively little rust drops from the roof and shell.

You can avoid most of the bother and expense of taking a tank out of service to replace corroded plates by using the Horton Double-Deck Floating Roof. It can be furnished with new tanks or installed on existing tanks whose shells are in good condition. For complete details about the Horton Double-Deck Roof, write our nearest office for a copy of Bulletin B.

The illustrations are (top) a view of a tank at a marketing terminal equipped with a Horton Double-Deck Floating Roof and (right) a cut-away view showing construction details of the roof. Both illustrations show clearly that the roof floats on the liquid in the tank.

• • •

The Horton Double-Deck Floating Roof does more than cut down corrosion . . . it also reduces the fire hazard, eliminates filling evaporation losses and greatly reduces standing storage losses. That's why—in addition to being used in tanks storing corrosive products—it's also recommended for tanks filled and emptied frequently, tanks in blending service, and tanks located in congested areas.

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Salt Lake City 4 563 West 17th South Street
San Francisco 4 1572—200 Bush Street
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Plants in: BIRMINGHAM, CHICAGO, SALT LAKE CITY, and GREENVILLE, PA.

sell. *Paint Notes*, 4, No. 2, 34-40 (1949).

The revised nomograph described enables the observed rating for chalking or erosion to be combined with that of checking, cracking or peeling, giving an "integrity" value. A figure for "decorative" value is obtained by combining general appearance with gloss or discoloration. These derived values may be combined to give an overall "utility" value for the paint in which the integrity value is given twice the importance of the decorative value. It is suggested that the time at which repainting is necessary can be estimated from the integrity figure.—RPI.

• On Location Tests

2.2, 8.1

Corrosion Test of Screen Wire at Sewage Works. R. S. Young. *Sewage Works J.*, 20, 550-551 (1948) May.

Report of two-year tests on screen wire of various materials covering Imhoff tanks, at Rhokana Corporation Works, Nkana. Types of screen were stainless steel (2 meshes), phosphor bronze, Monel and Everdur. Stainless steel was completely satisfactory. Other materials proved unsuitable.—INCO.

• Laboratory Tests

2.3, 6.2

Corrosion. M. G. Fontana. *Ind. & Eng. Chem.*, 41, 101A-102A (1949) Oct.

Discussion of nitric, lactic and maleic acid tests to evaluate heat treatment of stainless steels. Data is tabulated.—INCO.

2.3, 5.4

Flame-Sprayed Polythene Coatings Provide Exceptional Corrosion Resistance. *Mat. & Meth.*, 30, 81 (1949) Sept.

Exposure tests of one year's duration have shown no deterioration by hydrochloric acid, hydrofluoric acid, H_2SO_4 , and $HCOOH$. Polythene films, modified with graphite, were found to be free of porosity by spark tests in the neighborhood of 30,000 v, and various other short-time exposures to a variety of chemicals have been successfully withstood.—BLR.

Short-Time Testing of "Tin" Can Lacquers. (In German.) H. Niesen. *Archiv für Metallkunde*, 2, No. 7, 237-248 (1948).

Describes experiments made to test the mechanical and chemical properties of three different lacquers on blank and Bonderized sheet metal. Corrosion resistance was determined in distilled water, 2% salt solution, and 2% salt plus 2% acetic acid solution. The Bonderized sheets proved to be chemically more resistant than the blank sheets. Includes photographs, diagrams, and tabulated data. 10 ref.—BLR.

2.3

Contribution to the Study of the Corrosion of Metals. Marcel Pourbaix. *Bull. Soc. Roy. Belge. Ind.*, 1948, (A), No. 2, 97-108.

The value of potential measurements for studying the corrosion of metals in aqueous solutions is discussed, with particular reference to the behavior of iron in some acid, alkaline and chromate-containing solutions.—MA.

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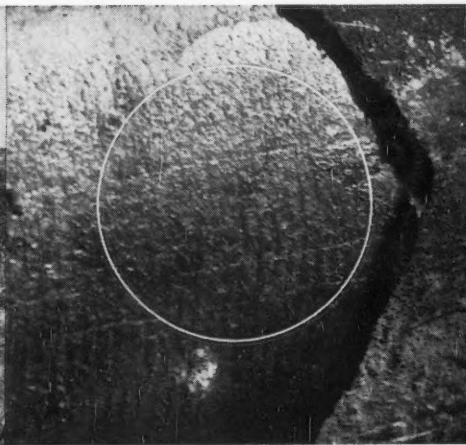
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✓ Memo: FOR CORROSION ENGINEERS

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copper, platinum) against a less noble and practically unpolarizable electrode. The two methods which supplement and confirm each other afford an insight into the local galvanic action between metal and oxide skin. Rates of oxidation and thickness of oxide skins were determined and rules governing the dissolution of different metals (especially of aluminum) are explained. Includes tables. 19 ref.—BLR.

2.3.5.3, 5.9

Determination of Porosity and Thickness of Conducting and Non-Conducting Surface Coatings. A. Vollmer. *Archiv für Metallkunde*, 3, No. 4, 145 (1949) Apr.; *Electroplating*, 3, No. 2, 66 (1949) Oct.

Resume of well-known methods. After prolonged experiments, 3 alkali-base solvents for stripping tin, lead, copper, brass, nickel, zinc, cadmium and copper-lead coatings from steel were developed. Vollmer developed a solution for stripping zinc from a steel base. Immediately on immersion the zinc is colored black and as it dissolves the bright steel surface becomes plainly visible. There is practically no gas evolution and, in consequence, the end point is readily visible as also is any lack of uniformity of thickness of the zinc plate. A coating 30 μ thick is dissolved in 15 min. Details of these solvents are not given.—INCO.

2.3.5.4

Electrochemical Studies of Protective Coatings on Metals. I—Electrode Potential Measurements on Painted Steel. F. Wormwell and D. M. Brasher. *J. Iron & Steel Inst.*, 162, pt. 2, 129-31 (1949); *J. Brit. Shipbuilding, R. A.*, 4, No. 7, 337 (1949).

A description is given of the experimental technique for periodical measurements of the electrode-potential behavior of painted steel immersed in a corroding liquid. Measurements have to be made over a prolonged period before any significance can be attached to the shape of the potential/time curve. A list of refs. is given.—RPI.

2.3.5.4

Testing and Evaluating Finishing Materials. E. M. Yacko. *Org. Fin.*, 9, 162-173 (1948) Apr.—BL.

● Instrumentation

2.4.7.8

Cable Testers Reveal Causes of Rope Wear and Failure. *Eng. Mining J.*, 150, No. 10, 72-75 (1949) Oct.

Mine research groups, rope companies and engineering companies in various parts of the world developed equipment to aid in the detection of hoisting rope deterioration and to disclose causes of rope wear. Four types are described: the Cyclograph which is the DuMont Cable tester; 2) the microtensiometer; 3) the Ontario testing machine, and 4) the decelerometer.—INCO.

2.4

Testing of Materials by Supersonic Methods. R. Pohlman. (In German.) *Zeits. f. Angew. Physik. Chemie*, 1, No. 4, 181-187 (1948). References.—BL.

2.4

Weatherometers. *Prod. Fin.*, 2, No. 5, 36-43 (1949).

A description of an apparatus which

essentially provides water spray and arc lamp irradiation. There are two standard models, viz., the twin arc and single arc. Various controls and meters are incorporated to enable the weathering cycle to be varied.—RPI.

2.4

Quality Extras—And Why. Rebecca H. Smith. *Iron Age*, 164, 75-77 (1949) Sept. 8.

Believes that more realistic approach to the problems of "quality" materials, particularly concerning acceptable defects, could greatly decrease present extra costs. Problems posed by Magnaflux, X-ray, and ultrasonic inspection methods are examined in detail.—BLR.

2.4

The Theory of Ultrasonic Materials Testing. N. E. Van Valkenburg. *Mech. Eng.*, 71, 817-820 (1949) Oct.

Reviews basic characteristics of ultrasonic waves. Outlines potentialities and limitations of application to materials testing. 13 ref.—BLR.

2.4

Electronics as Applied to Inspection and Testing. L. G. Ward. *Eng. Inspection*, 12, 24-31 (1948) Summer.—BL.

CORROSION TYPES & INFLUENCING FACTORS

● Types

3.2.3.5, 6.3

Stress Corrosion of Manganese Bronze Castings. T. L. Sheehan and H. E. Dickerman. *Foundry*, 76, 82-87, 190+ (1948) July.—BL.

3.2.5.3, 1.8

Mechanism of Exfoliation of Electrodeposited Surfaces. A. T. Steer. *Metal Fin.*, 46, 62-70 (1948) July.—BL.

3.2.3.7, 6.3

Internal Stresses, Tension Cracks, and Corrosive Decomposition of Brass. (In French and German.) R. Stettler. *Pro-Metal*, 2, 406-412 (1949) June.

Causes of the spontaneous cracking of semi-finished and finished brass products were investigated. Briefly mentions the effect of soldering and hot shortness on the propensity of brass and nickel-silver to cracking. Includes photographs and photomicrographs.—BLR.

3.2.6.2

Intercrystalline Corrosion in Chromium-Manganese Steel. (In German.) L. Wetternik. *Arch. f. Metallkunde*, 2, No. 9, 315-316 (1948).—BL.

● Factors Biological

3.3.8.9, 7.4

The Promotion and Acceleration of Metallic Corrosion by Micro-organisms. T. H. Rogers. *J. Inst. Met.*, 75, No. 1, 19-38 (1948) Sept.; *J. Inst. Met.*, 75, No. 12, 997-1006 (1949) Aug.

A report of laboratory investigations into the effect of micro-organisms and their metabolic products on the corrosion of ships' condenser tubes made of copper alloys. In the discussion, U. R. Evans suggested that the use of metallic

zinc paints might be a remedy for some of the corrosion caused by the presence of cystine in the water. The zinc would provide a large anode and might cause the coating of otherwise potential cathodes with zinc oxide. The author, however, commented that iron was more effective than zinc in removing cystine from sea water; also he thought the presence of zinc in condenser tubes undesirable as its corrosion products tended to lower the corrosion resistance of some of the other non-ferrous metals used.—ZDA.

cf: Engineering, 166, 623 (1948) Dec. 24.

3.3

Biologically Produced Corrosion Accelerators: Sulfur Compounds. T. J. Rogers. *Brit. Sci. News*, 2, No. 23, 322-326 (1949).

Reference is made to BNFMR researches which indicated the importance of the role of bacterial action in corrosion. The ways in which corrosion by bacterial action can be brought about are listed, and instances of two of these mechanisms are discussed: 1) the oxidation-reduction system cystine-cysteine, which has proved to be lively corrosion-accelerating system for copper-base alloys, and 2) production of bacteria by hydrogen sulfide. Methods of inhibiting corrosion of this type are briefly considered.—INCO.

3.3.6.5

Preservative Treatment for Lumber; Comparison of Various Copper Naphthenates Against Marine Borers. T. L. Shoemaker. U. S. Naval Base Report, 1948, No. 2098; *Prev. Det. Abs.*, 6, W 31 (1949).

No significant differences in effectiveness against marine borers were found among copper naphthenates manufactured from acids of different grades recovered from various crude oils. All copper naphthenates protected wood against borers for a limited time.—RPI.

3.3.5.4

Abnormal Development of Tunicates Attached to Glass Surfaces Adjacent to Anti-Fouling Paints. C. M. Weiss. *Ecology*, 29, 215-8 (1948); *Brit. Abs. B-II*, 1949, 238.

Sympyga viride does not grow normally when in proximity to surfaces treated with copper- and mercury-containing anti-fouling paints. The radial canals are stunted, peripheral canals do not develop, and the organism remains small. These effects occur 10 mm. from the paint edge.—RPI.

● Factors Physical and Mechanical

3.5

Effects of Internal Stresses. *Metal Prog.*, 56, 242-244 (1949) Aug.

Reviews last section of "Symposium on Internal Stresses in Metals and Alloys" (Institute of Metals, London, 1948). Deals with six papers on effects associated with internal stresses on a macroscopic scale.—BLR.

3.5

The Dynamics of Cavitation Bubbles. M. S. Plesset. *Calif. Inst. of Tech. J. App. Mech.*, 16, No. 3, 277-282 (1949) Sept.

Three regimes of liquid flow over a body are defined, namely: 1) noncavitat-

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ing flow; 2) cavitating flow with a relatively small number of cavitation bubbles in the field of flow; and 3) cavitating flow with a single large cavity about the body. The assumption is made that, for the second regime of flow, the pressure coefficient in the flow field is no different from that in the non-cavitating flow. On this basis, the equation of motion for the growth and collapse of a cavitation bubble containing vapor is derived and applied to experimental observations on such bubbles. The limitations of this equation of motion are pointed out, and include the effect of the finite rate of evaporation and condensation, and compressibility of vapor and liquid. A brief discussion of the role of "nuclei" in the liquid in the rate of formation of cavitation bubbles is also given.—TDD.

3.5, 7.10

Embrittlement of Roller Chains by Plating After Assembly. *Prod. Eng.*, 19, 105 (1948) Sept.—BL.

3.5

Cavitation Analysis by Electrical Analogy method. H. Rouse and M. M. Hassan. *Mech. Eng.*, 71, 213-216 (1949) March.

There exists no simple analytical method of designing for cavitation-free performance or even of predicting the performance of a given design. The electrical analogy method has been used quite frequently in the past for the convenient solution of problems in two-dimensional fluid motion. In principle it is based upon the fact that the flow of an electrical current through a homogeneous conductor follows the same pattern as the irrotational (i.e., non-viscous) flow of a fluid through a passage having a similar boundary form. Use of the electrical analogy method as described in the article makes it possible to study the pressure characteristics at any given boundary profile. The technique is also readily applicable to the study of many free-surface phenomena.—TIME.

3.5, 2.2

Cavitation and Pressure Distribution. H. Rouse and J. S. McNown. *Univ. of Iowa Students Eng. Bull.*, 1948, No. 32, 1-70.

Describes results of investigation of pressure-distribution about head forms under cavitating conditions. 31 different head forms were mounted on a 1-in. dia. cylinder held in the test section of a water tunnel and pressure measurements were made along the profiles of the heads. The resulting pressure distributions are given in the form of graphs, and comment is made on the results.—INCO.

● Factors Metallurgical

3.7, 6.4

The Effect of Nickel on the Corrosion Resistance of High-Purity Magnesium-Base Alloys. *Magnesium Rev. and Abs.*, 8, 46-52 (1948) Jan.

Describes a short investigation on the tolerance limit.—INCO.

3.7, 2.3, 5.3

Engineering File Facts No. 170: Attack on Four Heat-Resisting Alloys by Various Compounds After 17 Hrs. Heating in Air at 1500° F (815° C). *Mat. and Method.*, 28, No. 6, 105, 107 (1948).

Data sheets based on data furnished by the National Advisory Committee for

Aeronautics. The materials are S-816, S90, Hastelloy B, and Hayes Stellite No. 21.—MA.

3.7, 6.3

Metallurgical Aspects of Heat Checking in Brass Die Casting Dies. Part I. A. E. Nehrenberg. *Die Castings*, 7, 30-34 + (1949) Oct.

Heat treatment, properties and structure of steel dies were investigated in relation to heat checking resulting from pressure brass die casting. Includes tables, graphs, micrographs, and photographs. (To be continued.)—BLR.

3.7, 2.3

A Review of Current Alloy Casting Research. E. A. Schoefer, Alloy Casting Inst. *Ind. Heating*, 16, No. 10, 1771-1774 + (1949) Oct.

Among the important studies have been determination of 1) effect of corrosion resistance of minor variation in constituents of 18-8 stainless alloys, 2) proper heat treatments required for maximum corrosion resistance of 18-8 alloy, 3) effect of composition and heat treatment on mechanical and corrosion resistant properties of cast 12% chromium alloy, 4) proper balance of composition of 25% chromium-12% nickel alloy for optimum properties at high temperatures, 5) resistance to air and flue-gas corrosion of iron-chromium-nickel family of alloys from 1600-2000° F and 6) effect of composition on high temperature strength of 35% nickel-15% chromium alloy. Discussion includes standard composition ranges, lack of definitive test technique, test and test equipment devised, thermal fatigue test, neutral salt bath corrosion tests, study of welding characteristics.—INCO.

PREVENTIVE MEASURES

● Cathodic Protection

5.2, 8.4

Practical Corrosion Control on Gas Transmission Lines. G. R. Olson and H. V. Beezly. Paper before Southern Gas Assn., Biloxi, Miss., Apr. 20-22, 1949. *Corrosion*, 5, No. 8, 249-253 (1949) Aug.

Discussion includes increase in use of cathodic protection, small required current on well coated pipe lines, skill and experience required for application, list of common current sources, dependability of galvanic anodes, use of engine-driven generators, method of selecting a current source, example of small current demand, importance of insulating couplings, and necessity for sound engineering and efficient operation.—INCO.

5.2

Procedures Outlined for Cathodic Protection; Minimum Current Data Experiments. A. V. Smith. *Corrosion*, 5, xi (1949) Aug.

Questionnaire failed to provide satisfactory information concerning minimum currents necessary for cathodic protection. Hence an outline of proposed experiments for determining these currents is presented. Details of methods will be planned by a subcommittee. Following this, assistance in carrying out the experiments will be solicited.—BLR.

5.2

Cathodic Protection Against Corrosion. *Telephony*, 135, 18, 30 (1948) Dec. 18.—BL.

● Metallic Coatings

5.3, 4.2, 6.3

Rhodium Plating and Its Application to Reflectors. A. H. Stuart. *Electroplating*, 1, 88-90 + (1948) Jan.

The development of high-duty reflectors for searchlights and projectors has led to electroplating processes using rhodium. Measurements of reflectivity carried out at four angles of incidence and three intensities of light on reflecting surfaces of silver, lacquered silver, chromium, and rhodium confirmed the superiority of rhodium. After storage for 44 days in a room free from excessive fumes and dust, rhodium was free from tarnish and showed no reduction in initial reflectivity; the other surfaces, especially unlacquered silver, reflected noticeably less light than before the test.

Rhodium has a high melting point. Its hardness allows accumulations of dirt to be removed by soap and water without harming the surface. It is inert even in aqua regia and not affected by sulfur fumes.

Rhodium plating is usually carried out in a solution of rhodium sulfate in dilute sulfuric or phosphoric acid or a solution of rhodium phosphate in dilute sulfuric acid. Rigid chemical control is essential and is made commercially feasible by the availability of various proprietary rhodium phosphate concentrates. Operating temperatures range within 15-60° C; current densities may go as high as 100 amp. per sq. ft., although 20 amp. per sq. ft. is customary. A platinum anode is satisfactory. After a 0.5-hr. treatment, a bright film about 6 x 10⁻⁵ in. thick is produced.—PDA.

5.3, 6.2

Metal-Spraying Plant for Rolled-Steel Sections. *Engineering*, 168, 127, 132 (1949) Aug. 5.

Describes and illustrates British equipment for spraying a protective aluminum coating, 0.004 in. thick, on the surfaces of certain steel joists and other sections required for structural steelwork.—BLR.

5.3, 7.2, 4.6

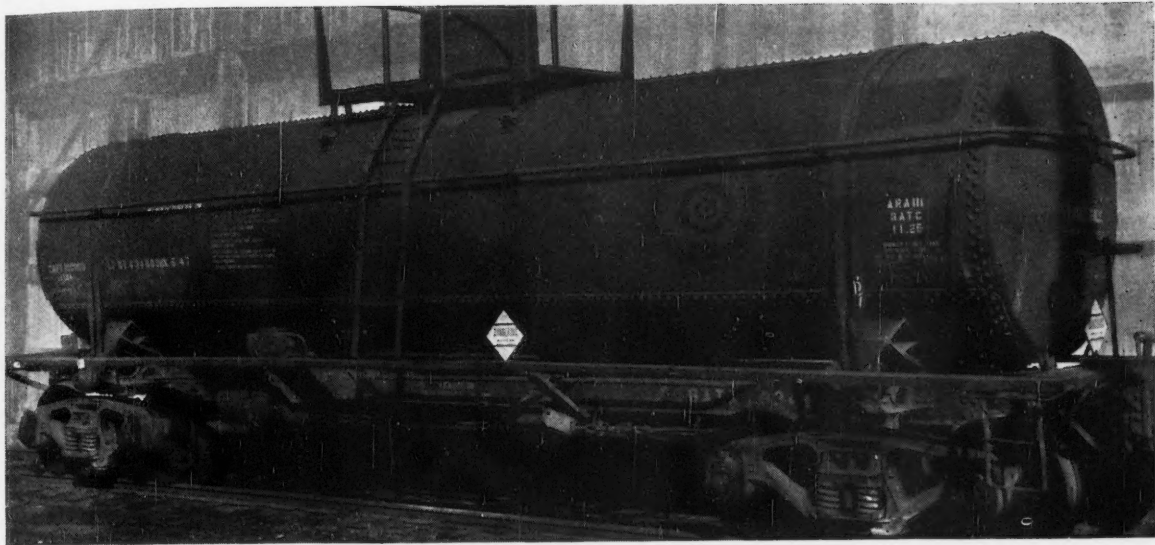
Tin Plating by Immersion Solves Difficult Problem. *Metal Fin.*, 47, No. 4, 66-67 (1949).

Describes the immersion tinning of copper water pipe and other plumbing fittings as an anti-corrosion measure. Details of the solution used are not given beyond the fact that it contains sodium cyanide, sodium hydroxide and stannous chloride.—MA.

5.3

Corrosion Resistance of Sprayed Metal Coatings. W. B. Meyer. *Corrosion*, 5, No. 9, 282-287 (1949) Sept.

The use of the metallizing process, whereby pure zinc and aluminum are sprayed onto a surface to protect it against corrosion, is discussed. As the wire emerges from the tip of the gun, it is rendered liquid by the jets of oxy-acetylene flame. In the liquid form, the metal can be projected by a stream of compressed air in much the same manner that other liquids are sprayed. As the small molten particles strike the large, cold mass of the part being coated, they immediately chill and freeze tight. In cooling, very thin oxide films are formed on the outside of each particle. The cohesion between particles is partly due to the adhesion of the molten

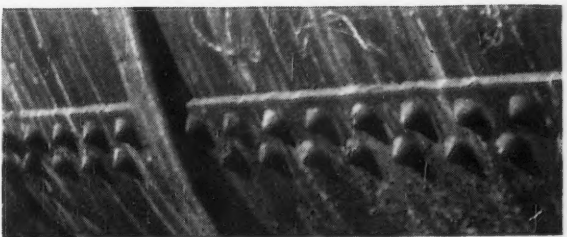


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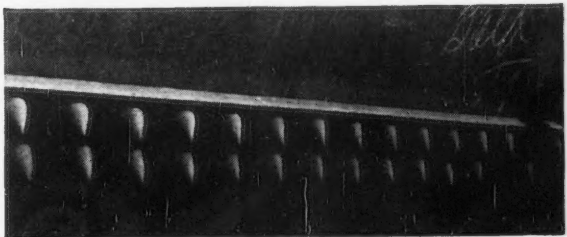
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particle to its oxide film, and to cohesion with the oxide envelope of the next particle. Although the initial cost is high for application of zinc or aluminum to metal structures, the service life is increased many times. Results of some tensile tests of metallized specimens are given. Methods of coating parts subject to furnace temperatures, and corrosive effects of hot gases are discussed.

5.3, 2.1, 2.3

The Conditions of Wear and the Control of the Quality of Hard Chrome Electrodeposits. P. Morisset. A review. *Rev. Gen. Mecan., (N.S.),* 33, No. 4, 142-146 (1949).

Owing to the varied conditions of service of hard chrome electrodeposits, which may entail dry or lubricated friction, abrasion, elevated temp., wide ranges of pressure and speeds, and corrosive influences, it is difficult to establish a measurable physical property which will determine the wear-resistance of the coatings under prescribed conditions. The position is further complicated by the effect of surface condition, particularly the structure, the "wetting" properties of chromium, its coeff. of friction, the nature of the material with which it is in contact, etc. Nevertheless, it is shown from a survey of the work of Wahl and Gebauer that surface hardness of the deposit has a fairly close correlation with resistance to wear as measured by the quantity of chromium removed by rubbing with emery paper. The effects of plating solution temp. and c.d., oxygen content, electrical resistivity, and heat-treatment of the coating on its hardness are also reviewed. Finally, the available methods for measuring the surface hardness of hard chromium deposits are critically discussed.—MA.

5.3, 2.3

The Protective Action of Sprayed Aluminum Coatings on Steel. G. Tolley. *J. Iron Steel Inst.,* 162, No. 4, 377-384 (1949).

Measurements were made of the electrode potentials of steel (0.18% carbon) specimens against specimens of aluminum sheet (99.5%) carrying a coating of sprayed aluminum 10 mil. thick. The specimens were immersed in distilled water and sodium chloride, sulfuric acid, ammonium sulfate and aluminum sulfate solutions of various strengths; the tests each lasted one week. In general the steel was anodic to the aluminum for the duration of the test, although the potentials decreased with time. With sulfuric acid in concentration greater than M/2000 and with aluminum sulfate in concentrations greater than 1.88×10^{-4} M, the aluminum was initially anodic, the potential increasing with time. With the M/2000 sulfuric acid and 1.88×10^{-4} M, aluminum sulfate solutions, the steel was initially anodic, but reversals of potential occurred after about 30 hrs. in both cases. In further experiments the loss in weight of a) uncoupled steel, and b) steel specimens coupled to sprayed aluminum, was measured when these specimens were immersed in 1) distilled water, 2) M/100 sodium chloride, 3) M/2000 ammonium sulfate, 4) M/2000 sulfuric acid; each solution was used plain and with the addition of aluminum chloride corresponding to concentrations of 3.75×10^{-4} and 7.5×10^{-4} M. With the uncoupled steel specimens, addition of aluminum sulfate to the solution caused inhibition of rusting and a marked in-

crease in the rate of corrosion. The film formed on the surfaces of the specimens immersed in solutions containing aluminum sulfate was found to be nearly pure aluminum hydroxide. The results obtained are discussed, with particular reference to the known facts that aluminum offers sacrificial protection to steel and that early rust staining of aluminum-sprayed steel often occurs. It is suggested that when the aluminum coating is initially cathodic, rapid corrosion of the coating occurs and causes it to become progressively less noble until a reversal of potential takes place; at this stage, sacrificial protection commences. If the coating is thin enough to be permeable to liquids and is "flooded" during the initial period of rapid attack, rusting of the steel occurs. Precipitation of corrosion products in the pores of the coating may prevent this early rusting.—MA.

MATERIALS OF CONSTRUCTION

• Non-Ferrous Metals Light

6.4

Aluminum and Aluminum Alloys.. B. Aluminum Wrought Alloys (General). (In German.) K. L. Dreyer, (FIAT Rev. German Sci., 1939-1946: *Non-Ferrous Metallurgy.* 1, 1948, 78-99).

Detailed abstracts (with references) are given covering the following: 1) Age-Hardening Effects, including a) internal alterations in structure, b) the influence of composition: aluminum-copper-magnesium, aluminum-magnesium-silicon, and aluminum-zinc-magnesium alloys, c) influence of pretreatment, i.e., degree of cold working, 2) Recrystallization Properties, including a) general review, b) influence of composition: alloys with copper and magnesium, magnesium, and zinc and magnesium, c) influence of pretreatment and method of production, d) occurrence and avoidance of coarse crystallization in the processing, 3) Mechanical Properties, a) Static Properties, including 1) the influence of composition and heat-treatment: the effects of manganese in aluminum-copper-magnesium alloys, of nickel in aluminum-copper-nickel alloys, and of zinc and magnesium in aluminum-zinc-magnesium alloys, 2) the effects of the position and method of production of the test pieces, 3) the influence of heat-treatment with or without loading: the hot proof, tensile and shear strengths, and the elastic moduli of many ternary alloys with copper, magnesium, nickel, manganese, and silicon, 4) the hot creep strength at 200°C.; the values for extruded specimens are: 0.5-1.5, 2-3, 6, and 8-11 kg./mm.² for aluminum-magnesium, aluminum-manganese, and aluminum-magnesium-manganese, aluminum-magnesium-silicon, and (in the age-hardened condition) aluminum-copper-nickel and aluminum-copper-magnesium alloys, respectively; values for drawn specimens are 0.5-1.5 kg./mm.² lower, b) Dynamic Properties, including 1) fatigue strength at normal temp. The method of production (whether extruded or drawn), position of the specimen, and the condition of its surface (whether polished or anodically oxidized) have great influence on the fatigue values, particularly with Duralumin alloys 2) fatigue strength at ele-

vated temp. For aluminum-copper-nickel alloys the fatigue values for 50 million reversals at 150° and 200°C. are ~15% and ~50%, respectively, lower than similar values at room temp.; at 200°C the alloys containing copper and nickel are superior to those containing magnesium, 4) Corrosion Properties, a) Surface Corrosion of Unclad Alloys, including 1) the influence of composition and method of production of the alloy, 2) resistance to various corrosive media. The action of sea water, weathering in cities, and laboratory tests (alternate immersion in 3% sodium chloride solution) are described. Unlike aluminum-copper alloys Duralumin alloys show no intercrystalline corrosion. Alloys with magnesium and/or manganese show little or no alteration in tensile properties after exposure to city atmospheres for 6 years. Alloys containing magnesium are sensible to attack by H-ions; against OH-ions they are more resistant than magnesium-free alloys. b) Clad Materials, including 1) protective action of various cladding alloys. Aluminum-copper-magnesium alloys can be satisfactorily clad with pure aluminum, aluminum-magnesium-silicon containing manganese, or aluminum-manganese, with a consequent increase in mechanical properties; aluminum-zinc-magnesium and aluminum-zinc-magnesium-copper alloys are best clad with aluminum-zinc alloys, 2) influence of thermal treatment, with special reference to diffusion of copper into the cladding material, 3) resistance to various corrosive media. Clad aluminum-copper and aluminum-copper-magnesium alloys show no deterioration in mechanical properties after weathering for 6 years. c) Stress-Corrosion. The resistance to stress corrosion depends on the surface condition of the specimen, the presence of stabilizers such as vanadium, chromium, titanium, copper, or manganese, heat-treatment, and the nature of the corrosive agent. Aluminum-zinc-magnesium alloys show good corrosion-resistance provided that zinc-magnesium is >6%.—MA.

6.4, 1.8, 3.7

Structure and Growth of Anodic Films on Aluminum and Zinc. (In French.) M. K. Huber. *Bulletin de la Société Chimique de France*, 1949, D183-D188, Mar.-Apr.

Investigation of the above revealed the existence of two types of anodic film on each of the above metals, a very dense film restricting the passage of the electrical current and a porous film. The crystallographic structure of porous films and their optical properties seem to be related to the crystal structure of the metal substrate. 17 ref.—BLR.

• Non-Metallic

6.5

Code of Practice for the Application of Timber Preservatives. SABS 05. South African Bureau of Standards. B.S.I. Monthly Information, p. 6, (1949) June.—RPI.

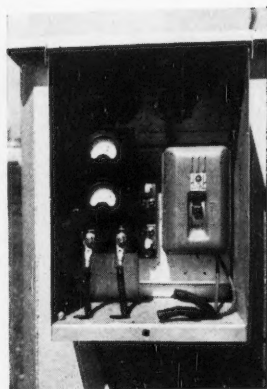
6.5

Deterioration of Wood and Wood Products. C. Hartley. Office of Naval Res. Wood Symposium, Washington, 1949, 15 pp.; *Prev. Det. Abs.*, 7, W 18-9 (1949).

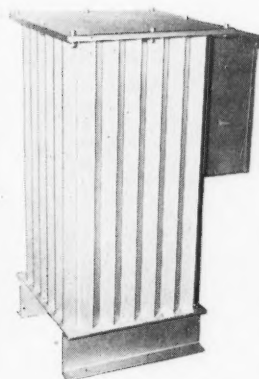
Conditions favoring decay of wood are listed. Paints are not normally considered effective decay barriers, as they themselves are susceptible to attack by fungi.—RPI.

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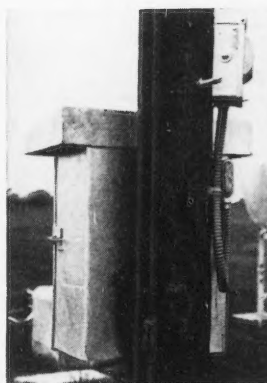
Cathodic Protection



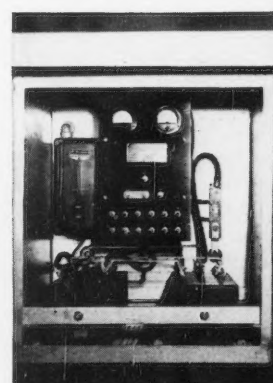
Oil-immersed, selenium rectifier—field installation showing meter and terminal box.



The NEW Westinghouse oil-immersed selenium rectifier—a 24V, 90 amp. unit just 43 inches high overall—36 gallons of oil suffice where 150 gallons were required in identical units of previous design.



Brance-Krachy air-cooled selenium rectifier in location showing pole mounting. (Method of connecting dc and ac leads optional.)



Typical unit construction—Brance-Krachy air cooled, selenium rectifier. Note sturdiness and easy accessibility.

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7.3, 5.7

Process Pressures Forging Higher. H. M. Boteler. *Chem. Eng.*, 56, No. 5, 133-4 (1949) May.

The reciprocating compressors made during the last decade have been designed for higher speeds, greater compactness and higher pressures. The design, operation and some applications of reciprocating compressors are mentioned. Methods of reducing the corrosion of compressors by corrosive gases, such as by removing the moisture are reviewed.

• Coils & Heat Exchangers

7.4, 5.9

Chemical Cleaning of Heat-Exchange Equipment. C. M. Loucks and C. H. Groom. *Trans. ASME*, 71, 831-836 (1949) Oct.

Use of chemical solvents for the above is described on the basis of the types of deposits, solvents available, and metals encountered. A number of case histories are described, illustrating chemical cleaning in various industries. 16 ref.—BLR.

7.4, 6.2, 4.4, 4.3

Aluminum Condenser and Heat Exchanger Tubes. J. S. Hamilton and J. J. Bowman. *ASTM Bull.*, 1949, No. 159, 44, July.

The two alloys covered in ASTM Specification B 234-48T for use in condensers and heat exchangers are designated M1 and M1 Clad, and differ principally in that M1 Clad tubes are more resistant to perforation. For most applications, M1 tubes are adequately resistant to corrosion but when salts of heavy metals such as copper, tin, nickel, or lead are present, the contaminated water may induce severe pitting. The superior resistance of M1 Clad tubes results from an Alclad coating on the inside surface of the tube applied during the initial stages of manufacture. The specification covers tubes in a temper which combines good strength with a satisfactory level of workability. When the operating temperature range is not too great, the aluminum-alloy tubes can be used in conjunction with steel tube sheets without danger of working loose. Allowable working pressures for the tubes are tabulated. Aluminum-alloy condenser and heat exchanger tubes have been used successfully in the production of acetic and other aliphatic acids, acetaldehyde, naval stores, vegetable oils, formaldehyde, hydrocyanic acid, in the ammonia recovery steps of the soda ash process, in condensing sweet and sour hydrocarbon gases and liquids, in furfural and other types of lubricating oil-solvent extractions processes, and in condensing steam. They have been used in air- and water-cooled atmospheric heat exchangers, air and natural gas compressor intercoolers and after coolers, lubricating oil and jacket water coolers, and numerous other types of heat exchangers.—ALL.

7.4, 3.5, 6.2

Destruction of an Admiralty Tube Bundle by Stress Corrosion in the Presence of Mercury. B. B. Morton. *Corrosion*, 5, No. 7, 244 (1949) July.

Brief report on the stress corrosion cracking of several hundred 14-gauge Ad-

miralty metal (70 Copper-29 Zinc-1 tin) heat exchanger tubes in a petroleum refinery, due to traces of mercury metal carried from a seal-pot. No data given concerning the fluids used, but the temperature of the tube metal was 150°C. Photo micrographs.—BNF.

• Structural Shapes

7.6, 4.3

An Unusual Defect in a Boiler Support. *Vulcan Mag.*, 1947, 145-147, July. *Power*, 92, No. 3, 128 (1948) Mar.

A vertical web of the main girder of a steam-generating unit was corroded by poor ventilation and flue gas. Samples of scale and dust showed iron, silica and were magnetic. Illustrations.—INCO.

7.6, 8.4, 5.3

Internally Insulated Pressure Vessels, Piping, for High Temperature Service. P. E. Darling. Paper before ASME Ann. Mtg., Petrol. Sect., Houston, Oct. 6-8, 1947 *Petro. Proc.*, 3, No. 4, 339-340 + (1948) Apr.

Due to high cost of alloy steels, internal insulation for vessels and piping used for high-temperature service was developed. Examples are given of factors involved and problems met in hydro-forming and fluid catalytic cracking unit using internal insulation. Study of the situation narrowed the choice of materials to 18-8 liner or to developing a suspended refractory tile installation. Failure of 18-8 liner and superior performance of carbon steel liner resulted in use of Insulag, a refractory tile installation. Diagram of cross-sections of insulations are included.—INCO.

7.6, 4.7

Crucibles for Remelting of Cast Iron. (In French.) Gabriel Joly. *Fonderie*, 1591-1592 (1949) May.

The problem of increasing the life of the above was investigated. Proposes use of stainless steel or white cast iron. Chemical composition and comparative costs are indicated. Methods for improvement of the durability of crucibles in general are proposed.—BLR.

7.6, 5.1, 3.5

Sulfur, Dew Point and Boiler Availability. Stephen Juhoag. *Combustion*, 20, 155-58 (1949) June. Translated and condensed from *Tennick Tidskrift* (Sweden) Jan. 22, 1949.

Sulfur content of fuel and flue gas is discussed in relation to deposits and corrosion of boiler and superheater surfaces. Problems of dew-point measurement are outlined, and a dew-point meter developed by the author is described. The economics of corrosion-resisting materials is considered and means of reducing corrosion difficulties are analyzed.—BLR.

7.6, 4.3, 3.4, 3.5

Causes of Flue Gas Deposits and Corrosion in Modern Boiler Plants. Paper by W. F. Harlow, read at a joint meeting of The Institution of Mechanical Engineers and The Institution of Electrical Engineers, 4th March, 1949. Condensation: *Engineer*, 187, 271-3 (1949); discussion 277-279.

This paper is intended to be amplification and continuation of the author's previous paper entitled "Causes of High Dew-Point Temperatures in Boiler Flue Gases" read in 1943, in which attention was drawn to the phenomenon of the catalytic production of sulphuric acid in

flue gases by their passage over heated iron surfaces. At that time the full importance of these findings was not apparent, but evidence is now submitted to show that, in addition to causing deposits and corrosion by the deposition of acid in air heaters and economizers, this phenomenon is primarily responsible for the flue-gas deposits and corrosion in all parts of boiler plants. Experiments are described which show that when flue gases are passed over sand-blasted steel-surfaces which are maintained at the gradation in metal temperatures which can occur through a modern boiler plant, sulphur trioxide is produced at the high temperature surfaces, causing sulphuric acid to condense on the cooler surfaces. When the maximum surface temperature is moderated no appreciable formation of acid occurs. It is believed that the interaction of the sulphur trioxide in the generation zone, and the condensed acid in the cooler zone, with the various constituents of the fuel ash and the metal of the heating surface, can explain all the numerous deposit and corrosion effects which have been the subject of research work both here and abroad during recent years. The high surface temperatures which are necessary for the catalytic action to occur are largely due to the general advances in operating temperatures and pressures, and in some measure to "surface combustion" taking place on the tube surfaces, elevating their temperatures above that which they would acquire if swept only by inert gases. Although the advance in steam and water temperatures is considered to be a primary factor in these difficulties, many other contributory factors, particularly the nature of the fuel, play an important part.—TIME.

• Electrical & Telephone

7.7

Erosion of Electrical Contacts on Make. L. H. Gormor & F. E. Haworth, Bell Telephone Lab. *J. Applied Physics*, 20, No. 11, 1085-1109 (1949) Nov.

Erosion caused by discharge of a capacity as contacts are brought together, is of fundamental importance in the performance of relay contacts. Nature of discharge which produces the erosion and relationship of the measurement and the discharge nature to circuit parameters, ambient gas and other variables are discussed. Contacts concerned are made of palladium, platinum and gold. Graphs include volume of contact metal transferred per erg of condenser energy plotted against various factors. Photomicrographs of gold and platinum electrodes after a discharge of 11 ergs at 48 volts are given.—INCO.

• Miscellaneous

7.10, 6.2

Stainless Steel Thermostat Wells. *Electrical Mfg.*, 44, No. 4, 182 (1949) Oct.

Stainless steel case protects immersion type thermostats that must operate under adverse conditions. Thermowells offer protection from excessive pressures, physical blows, ambient effects on the heads when they protrude from the medium being controlled and other external factors that affect operation, corrosive liquids or atmospheres and abrasion. Thermowells permit removal of thermostat from tanks or other containers without need for removing liquids or gases they contain. Mfd. by Fenwal, Inc.—INCO.

7.10

The Behavior of Paste-Coated Storage Battery Plates During and After Extended Periods of Non-Use. (In German.) E. Hoehne. *Archiv fur Metallkunde*, 3, 185-191 (1949) May.

Presents results of an investigation of the above with respect to corrosion and deterioration over periods of non-use up to 400 days. Includes photographs, graphs.—BLR.

INDUSTRIES

• Group I

8.1, 6.4

Aluminum and the Transport of Refuse and Sewage. *Light Metals*, 12, 470-474 (1949) Sept.

Presents results of an investigation of corrosion problems in the use of certain light-alloys in the construction of special vehicles for the above. Includes tables and photomicrographs.—BLR.

8.1, 4.6, 3.4, 3.6

Conference on Electrochemistry and Corrosion Research at the Berlin Technical University on 22 February, 1949. *Metall*, 3, Nos. 9/10, 155 (1949).

L. W. Haase spoke on "The Influence of Oxygen on Reactions at the Internal Surfaces of Water Mains," and discussed the effects of molecular and nascent oxygen, the pH and rate of flow of the water, depolarization, time, and the type and properties of the corrosion products formed.—MA.

• Group II

8.2, 5.9

Chemical Cleansing of Power Plant Equipment. C. S. Darling. *Mech. World*, 124, 655-659 (1948) Dec. 10.—BL.

• Group III

8.3

Candy Progress. F. Buese. *Food Industries*, 21, 97-104. (1949) MM.

Description of modern candy-making and chocolate-enrobing equipment. Mentions, inter alia, chocolate melters with capacities of 100 to 2000 lb., of stainless steel for improvement in appearance and sanitation. In cooking installations, revolving pans for pan goods are now made of stainless steel instead of copper.—INCO.

8.3, 4.4, 3.7, 6.1

Corrosion Resistance of Various Alloys in the Manufacture of Vinegar. R. Dubrisay. *Bull. Tech. Vinaigrette*, 1949, No. 1, 79-80, Jan.-Mar.

Report of tests, under working conditions, on some stainless steels and phosphor bronzes. In some cases the influence of surface condition and the resistance of welded joints were determined. Results obtained with all the stainless steels were satisfactory (straight chromium-nickel, chromium-nickel containing titanium and chromium-nickel containing molybdenum). Phosphor bronzes were attacked, especially those containing lead. Behavior of cast iron was so bad that no details are given.—INCO.

8.3, 4.6, 3.6, 6.2

Corrosion Characteristics of Light Metals Used in Sprinkler Irrigation

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Systems. *Light Metal Age*, 7, Nos. 5, 6, pp. 14-15, 23 (1949) June.

The comparative strength and lightness of aluminum and its high resistance to general corrosion make it suitable for use in portable sprinkler irrigation systems. A contract was signed on June 25, 1945, between the State College of Washington and the Bonneville Power Administration to undertake a study of the corrosion characteristics of metal pipe used in sprinkler irrigation systems in the state of Washington. Of the aluminum alloys tested, 63S-T6 and 61S-T6 give good service. In the Moses Lake region of the state, the irrigation water contains enough copper, or other heavy metals in solution, to cause galvanic corrosion. This has proven sufficiently severe in some instances to shorten appreciably the life of aluminum pipe. Galvanic corrosion has been combatted experimentally by various methods including the use of protective anodes, commercial coatings and anodic claddings. Research will be continued to find the most effective method of combatting galvanic corrosion in those areas where it occurs.—ALL.

8.3
Advanced Methods Bring Top Efficiency in Huge Cannery. C.R. Havigherst. *Food Ind.*, 21, 53-57, + (1949) Jan.

Description of Hawaiian Pineapple Co's 57½-acre plant in Honolulu for handling nearly 5 tons of pineapples a minute. Core cylinders of pineapples trimmed on 20-ft. stainless steel trimming tables; slices later inspected, graded and packed on stainless steel packing tables.—INCO.

8.3, 5.8
Dairy Cleaners. M. A. Lesser. *Soap & San. Chem.*, 24, No. 5, 40-43, + (1948) May.

Discussion of detergents in dairy industry. Some detergents are corrosive to materials. Caustic alkalis are not used for can washing because they are too corrosive to tin. In one formula given, describing a cleanser for milk vessels, sodium sulfite is included as a corrosion inhibitor.—INCO.

● Group IV

8.4
Protective Layer Formation in Condensate Wells. N. Haskerman and D. A. Shock. *Univ. Texas. Gas*, 24, No. 2, 40-44 (1948) Feb.

Protective films which are laid down in natural gas condensate wells by the resultant action of some constituent present in the fluid of the well are discussed. Injection of commercial naphthenic acid or sodium dichromate gives a protective layer similar to those found in non-corrosive wells. It is suspected that a reaction occurs between steel and naphthenic acid with the formation of iron salt which remains on the surface as an amorphous, coherent, adherent film. Sodium dichromate gives protection through the formation of a protective reaction product of reduced chromium which deposits on the steel surface.

8.4, 4.4
Organic Acids Produced by High Pressure Gas Wells. H. L. Lochte, C. W. Burnam, and H. W. H. Meyer. *Petro. Eng.*, 21, C34, + (1949) Aug.

Presents results of a laboratory study of the acids found in the water phase from the Katy field of Humble Oil and Refining Co.—BLR.

8.4
Stopping Refinery Corrosion. API Symposium on Stopping Refinery Corrosion, Refinery Division, Mid-year Mtg., 1948, Houston, Texas. *Petro. Proc.*, 4, No. 5, 540-543 (1949) May.

Condenser versions of the following papers are printed:

Hydrogen Blistering Reported by Several Oil Companies, by M. H. Bartz and C. E. Rawlins, Phillips Petroleum Co.

Hydrogenation-Plant Steels, by G. A. Nelson, Shell Development Co.

Cathodic Protection Within an Oil Refinery, by D. Holsteyn, Shell Oil Co.

Corrosion and Stress Factors in Piping Expansion-Joint Failures, by H. F. Brown and W. M. Goryl, Standard Oil Development Co.

Subject included destruction and damage from attacks by hydrogen, stress, and stress corrosion of expansion joints in catalytic cracking units, and general protection of ground and underground refinery equipment by cathodic methods. In steel corrosion by ammonia, nitriding begins at temperatures above 850° F and occurs on steels containing more than 2% chromium. For protection against nitriding, an alloy containing 16% chromium, 15% nickel, 3% silicon, and 0.4% carbon has been reported satisfactory at 950° F and 12,000 psi. An alloy containing 57% nickel, 12% chromium, and 1.7% tungsten is understood to be included in the Claude synthesis of ammonia, with a life between 2000 and 20,000 hr. depending on the quality of the casting.—INCO.

8.4, 6.2, 5.3, 5.4, 7.8

Use of Aluminum in the Petroleum Industry. *Light Metals* (England), 12, No. 138, 372-381 (1949) July.

Aluminum heat-resisting paints are used in refineries on furnaces and steel stacks where the paint preserves the metal work of the furnace from corrosion, reduces the amount of heat lost by radiation and maintains good appearance. Among other uses of aluminum paint in the oil industry are the painting of pipelines, structural steel work of buildings, the steel work of refinery processing units, woodwork, and the oil field drilling equipment. Aluminum paints based on either a bituminous or coal tar vehicle are used for the protection of storage tanks and pipelines. Bituminous and coal tars are characterized by their high water resistance, and not only is this enhanced by the incorporation of aluminum powder, but the latter also protects the vehicle from direct sunlight which would normally cause rapid deterioration. The leafed film of aluminum seals the bitumen surface. The aluminum-bitumen and aluminum-coal tar paints are used where there is a high concentration of acid fumes and where stagnant water collects.

Aluminum foil has been used for storage tanks where the steel shell is coated with thick bituminous paint, which supplies good adhesion for the foil. Aluminum foil is also used outside of storage tanks as a protective coating and as a means of reducing evaporation losses from the tank. It is put on the inside walls of crude-oil storage tanks to prevent corrosion by the sour oil, and on storage tank roofs. In joining an aluminum roof to a steel tank shell, soft aluminum strips are used as gaskets. Manhole covers, valves and nails have all been made of aluminum for use on steel tanks. Because of its corrosion

resistance and non-sparking properties, aluminum is used in flame arresters which are made of alternate layers of flat and corrugated aluminum sheet, fitted on storage tank roofs. Corrugated aluminum roofing sheets and interlocking aluminum shingles are being used for buildings in the oil fields.—ALL.

8.4, 5.4, 5.9

The Protection and Maintenance of Petroleum Property. C. R. E. Merkle, du Pont de Nemours & Co. *Petro. Ref.*, 27, No. 5, 134-137 (1948) May.

Report on the protection and maintenance of petroleum property points out that this practice is dependent on proper application and selection of protective coatings. Fundamental requirements of protective coating maintenance are surface preparation, proper conditions for coating applications, adequate film thickness, and material selection. Silicone aluminum heat resistant finishes are now available.—INCO.

8.4, 6.1, 6.2

Corrosion Protection of Oil-Refining Equipment. H. P. Zeh, Standard Oil Co. of California. Paper before Western Metals Congress & Exposition, Los Angeles *Oil & Gas J.*, 48, No. 4, 99-100+ (1949) Aug. 11.

Discussion includes record of corrosion experience, corrosion reference points and plant corrosion tests, corrosion tests in pilot plants, and expected life of equipment which influences material choice. One type of corrosion reference point consists of two short lengths of Type 316 stainless steel rod laid on vessel surface two inches apart and parallel to each other. Materials usually exposed in oil-refining units are: cast iron, Ni-Resist, 5% chromium-molybdenum steel, Type 304 steel, Type 316 steel, Monel, 30% copper-nickel, Admiralty metal.—INCO.

● Group VI

8.6

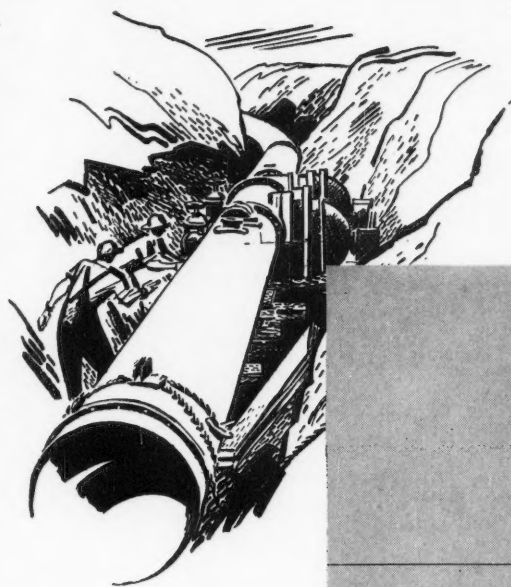
The Flax Wet Spinning Frame as a Source of Catalytic Damage in Bleaching. W. Honneyman. *Chem. & Ind.*, 1949, No. 39, 663-667, Sept. 24.

Occasional random destruction of threads during peroxide bleaching of cloth was found to be due to catalytic action of traces of copper compounds. Investigation showed that these were incorporated in the yarn during wet spinning, and were corrosion products caused by use of composite copper/brass equipment; it is essential that only one metal (stainless steel or brass) be used, and that pipelines be insulated. Data are given for the potential set up by 7 different couples, the effect of the water supplied, etc.—BNF.

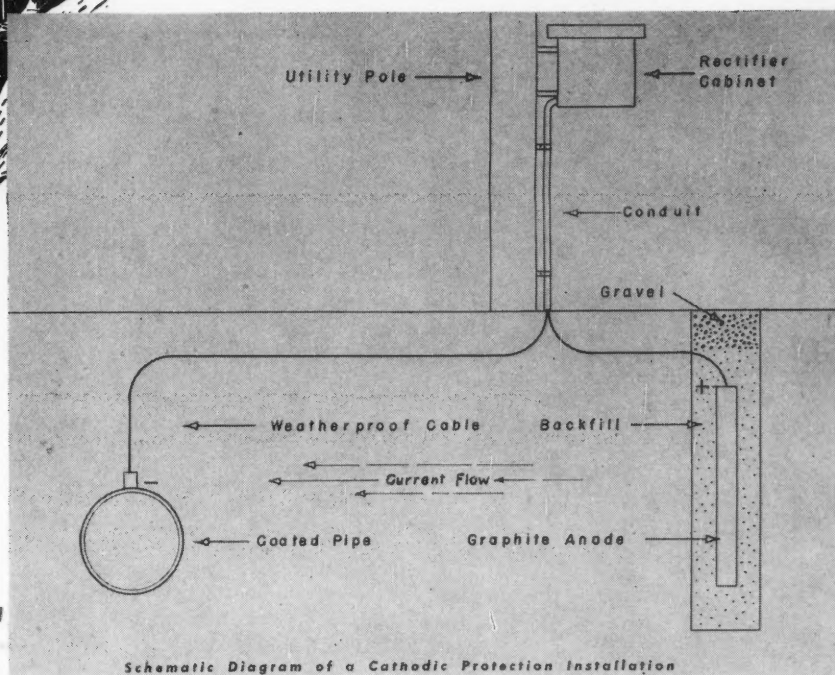
8.6, 4.4, 6.1, 6.2

The Warp Sizing of Nylon for Weaving. *Rayon Textile Monthly*, 29, No. 6, 75 (1948) June.

In discussion of polymethacrylic acid, textile size (PMA), solutions are non-corrosive to stainless steel and aluminum. Other metals may be attacked when in direct contact. Non-stainless steel can be used if no heavy size deposits are built up.—INCO.



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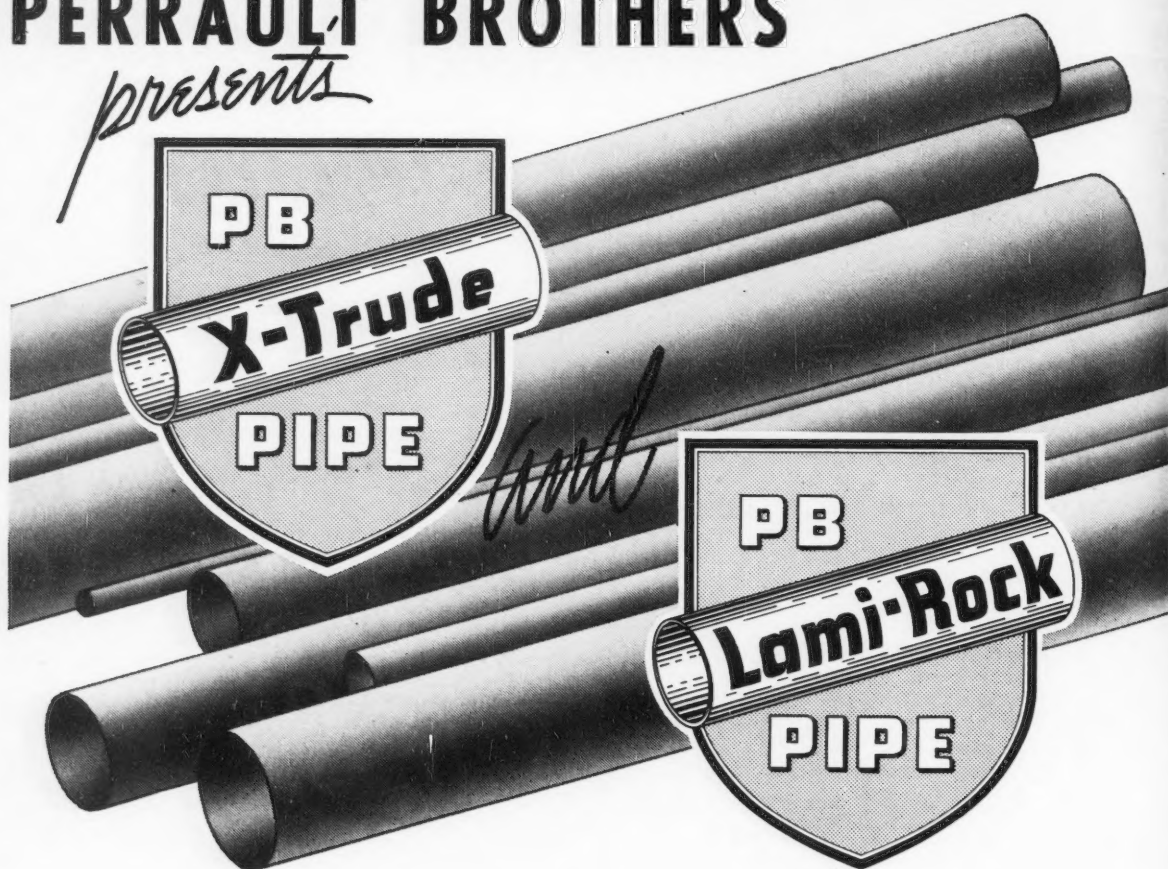
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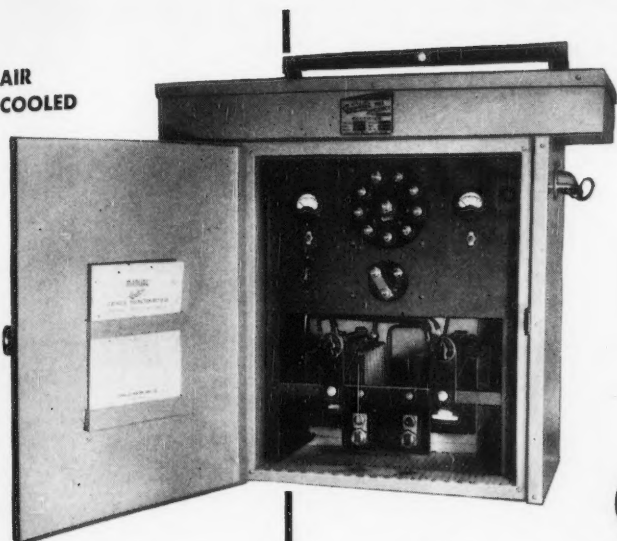
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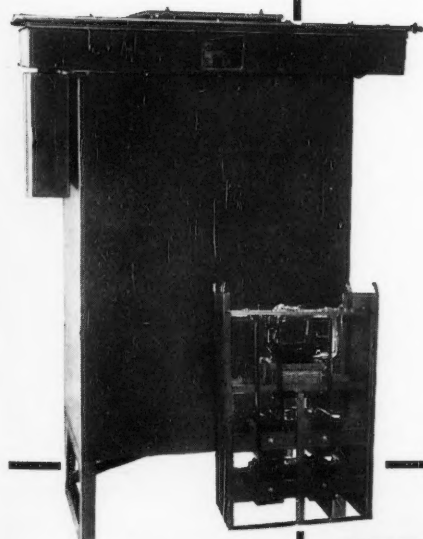
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• Group VIII

8.8, 7.6, 7.4, 7.3, 6.1

Gas Conserved to Make Chemicals. A. L. Foster. *Petro. Eng.*, 21, No. 3, C7-C10, C12 (1949) Mar.

Formaldehyde is highly corrosive and special materials are used to prevent destruction of equipment. Fractionators, vapor lines, condenser coils, exchangers and pumps handling formaldehyde are of stainless steel.—INCO.

8.8, 2.2, 2.3, 6.1, 6.2, 5.3, 5.4

Material Selection and Combating Corrosion in the Chemical Industry. H. C. J. de Decker. (In Dutch.) *Metalen*, 3, 1-11 (1948); *J. Iron Steel Inst. Abs.*, 161, 167 (1949).

The wide variety of conditions which the constructional materials for the chemical industry have to meet are discussed from the corrosion point of view. The planning of corrosion tests for many materials, including metal and protective coatings, is also dealt with.—MA.

8.8, 7.8, 4.3

Mechanical Engineering in the Chemical Industry. F. H. Bramwell. *Inst. Mech. Eng. Advance Copy*, May, 1949, 8 pp.

This paper deals with materials of construction for chemical plant, pumps and compressors, containers, etc.; it is confined to industries established on Merseyside: H_2SO_4 , Chlorine, NaOH and bleaching powder production. An abridged version is published in *Engineering*, 167, 597-600 (1949) June 24.—BNF.



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8.8, 6.2, 3.4, 3.5, 5.3

Physical and Corrosion Characteristics of Lead in the Chemical Industry. K. H. Roll. Lead Industries Assn. Paper before NACE, 5th Ann. Conf., Cincinnati, Apr. 11-14, 1949. *Corrosion*, 5, No. 8, 261-270 (1949) Aug.

Physical and corrosion characteristics of lead particularly with respect to its use in chemical industry are discussed in detail. Chemical properties are described and include effects of concentration, temperature, mixed and impure corrosives. Characteristics, such as fatigue, recrystallization, stress corrosion and galvanic corrosion are given along with specifications for chemical and alloyed lead. Physical properties including temperature and pressure limits and effect of flow rate are detailed. Methods of fabrication and recommended practices for soldering and welding, installing sheet lead, homogeneous and acid-brick linings are described along with latest developments in lead, lead-lined pipe, lead heating coils, castings and valves. Economic aspects of repair and replacements of lead are also given. It is demonstrated throughout that physical characteristics of lead are of equal importance to its corrosion characteristics in determining its applicability in corrosion resistant equipment. 18 references.—INCO.

8.8, 6.2, 6.3

A Process for the Production of Iron-Free Alum—Part 1. Laboratory Development. E. A. Gee & W. K. Cunningham. Bur. of Mines. U. S. Dept. Interior, Bur. of Mines, R. I. 4191, Feb., 1948 27 pp.

Acid processes present difficulty in selecting materials of construction and corrosion tests were conducted on mild steel, nickel, Monel, Inconel, lead, Tobin bronze and 18-8 (tabulated). Stainless steel and lead were selected because the former could be machined to a high degree of precision for moving parts, and the latter provided an acceptable metal for storage tanks and other stationary equipment. Due to scarcity of alloy steels during the emergency, type 304 was used for construction of a number of pilot-plant units, but did not prove completely satisfactory.—INCO.

8.8

The Surface Protection of Metal Equipment Used in the Superphosphate Industry. A. Kuflerath. *Metalloberfläche*, 3, No. 2, 40-42 (1949).

A brief review.

8.8

Laboratory and Technical Production of Fluorine and Its Compounds. H. R. Leech. *Quarterly Reviews*, 3, No. 1, 22-35 (1949).

A review. 53 ref.—BLR.

• Group IX

8.9

Corrosion Problems of the Automotive Engineer. F. L. LaQue and E. J. Hergenroether (International Nickel Co.) (Preprint No. 337, S. A. E. Summer Meet., French Lick, June 5-10, 1949) 24 pp. \$0.25. *Abst. SAE Jour.* 57, No. 8, 35-37 (1949) Aug.; *Automotive Inds.*, 101, No. 1, 44 (1949) July 1.

A general discussion of automotive corrosion problems covers: corrosion of the car body and the effects of salt treatment of roads; corrosion of car underbodies due to poor ventilation; composition of

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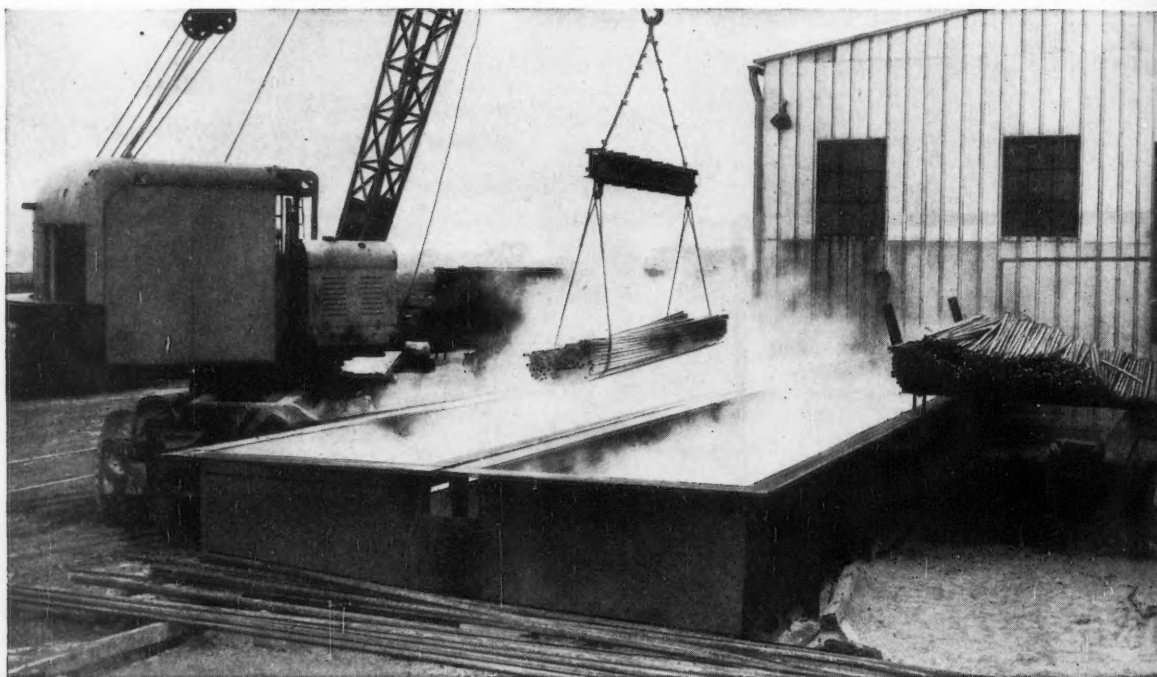
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steel which can encourage or combat corrosion; stray electrical currents in the car body; resistance of wetting, fastenings, decorative trim, engine cylinders, mufflers and tail pipes, cooling system, and liners to corrosion; corrosion by lubricants; and fretting corrosion. Through proper selection of available materials for the various parts, use of coatings and inhibitors, and modifications of design, construction details and conditions of use, much can be done to control corrosion. Tables give typical thicknesses of nickel coatings on steels for automotive applications; comparative resistance of Ni-Resist and cast iron to corrosion by chemicals encountered in exhaust condensate; and comparative service records of Ni-Resist and other cylinder materials. Graph show the effect of shelter on metal specimens exposed at Bayonne, of copper content on atmospheric corrosion of steel exposed 18 months, and of thickness on protective value during the first 15 months exposure in marine locations of nickel specimens. Photographs show various effects of corrosion. (23 references.)

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